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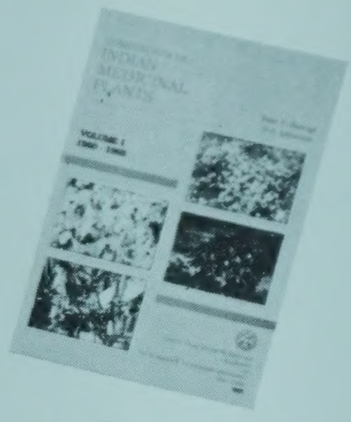
Compendium of Indian Medicinal Plants



4 Vols.

by R P Rastogi and B N Mehrotra

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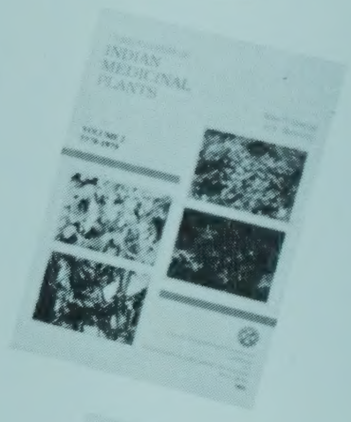

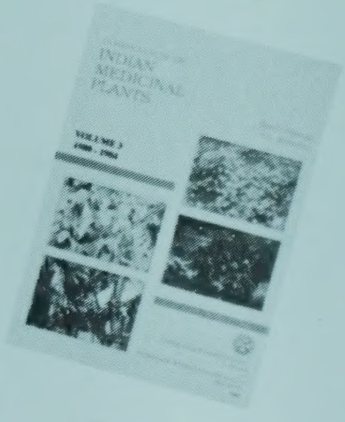

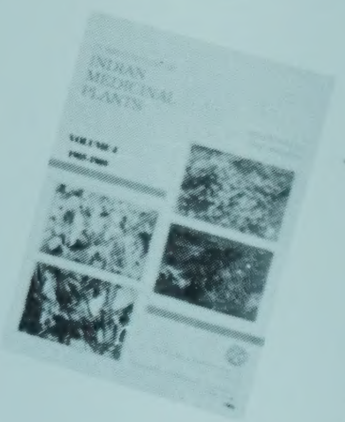

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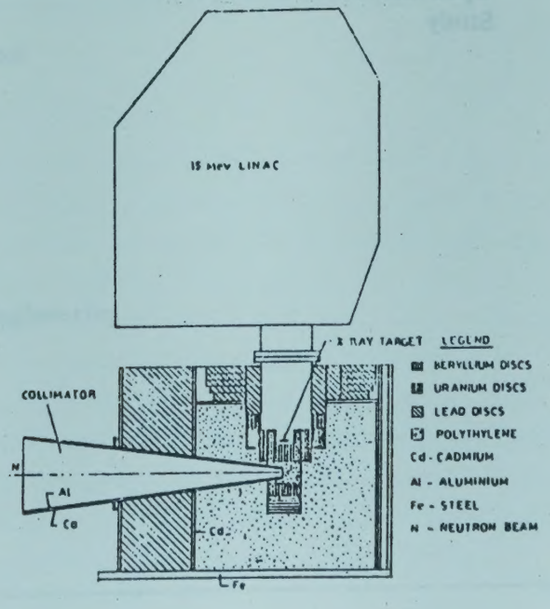

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Technical Manpower and its Development in Assam

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Institute of Advanced Study in Science and Technology, Khanapara, Guwahati 781 022, Assam, India
Received: 16 May 1996; Revised and accepted: 3 March 1997

Supply of technical manpower and its deployment in Assam have been analysed . The statistical analysis of the data indicates that most of the employed engineering degree and diploma holders are performing technical functions.Introduction

Introduction

Human resources constitute one of the major inputs in any human activity, besides equipment, machinery, raw materials and other infrastructural facilities. It is generally believed that human resources contribute, to a considerable degree, towards economic growth. Thus one of the important facets for realistic economic planning and rapid growth is identification of the types of technical and professional skills needed and planning for their development.

In India, and in particular, in Assam, one of the major problems is the generation of employment both in the rural and urban sectors. This is closely linked with industrial, agricultural and in turn, economic growth, where appropriate use of science and technology is believed to play a vital role. Therefore, there is a need to create an adequate supply of qualified scientific and technical personnel and to utilize these personnel for accelerating economic/industrial development.

These needs were articulated in the relevant policies of the Government of Assam and are discussed in the statement of the industrial policy of Assam 1991CC4DD .

Inspite of the above policies and notwithstanding four decades of planning, the development of the state has not so far reached the desired extent. The state economy is still dominated by primary sector and the secondary sector has not reached the desired level due to lack of infrastructural development but it is expected to receive a big boost in the coming years through large investments, more importantly, for development of infrastructure, industry and irrigation.

Now, a question arises whether the expansions in science and technology manpower, in general, and engineering/technology manpower, in particular, enhance industrial and economic growth and thereby lead to increased employment, both for rural and urban sectors, since there is a widespread view that the technical and skilled manpower accelerate industrial development and growth. At this stage, it is not easy to answer such a question, as there is much unemployment, underemployment or disguised unemployment both in rural and urban sectors.

This paper focusses on the analysis of the supply and utilization of technical manpower, based on the available statistical data. Inspite of the limitations of data and indirect relationship between economic development and technical manpower, the ensuing discussion will elucidate, to some extent, the gaps between educational infrastructure / planning and economic development.

Methodology

Estimates have been worked out on the basis of primary and secondary data. Available secondary data have been used to obtain realistic estimates by statistical technique and taking into account demographic trends. Primary data have been collected on sampling basis from organisations/institutions/PSUs and medium and small industrial units etc. Data have also been collected from educational/technical institutions, employment and labour bureau etc. These refer to the Report (IASST, 1995) from which relevant data have been taken for this paper.

Growth of Engineering Institutions

The post independence years saw quite an impressive growth in the number of universities, engineering colleges, polytechnics, professional and training

institutions offering variety of courses at various levels in different disciplines.

In 1947,there were no universities, engineering colleges and only one polytechnic in Assam. In 1995, there are 5 universities (including two central universities and one agricultural university), 4 engineering colleges (including one IIT), 3 AMIE coaching centres, 7 polytechnics, one textile institute and one handloom technology institute.

Intake Capacity

An attempt has been made to build up the growth profile of Actual Intake capacity of engineering/technology 'graduate' and 'diploma ' courses; This is shown in Table 1.

As a consequnece of the increase in actual intake capacity, number of engineering and technlogy graduates and diploma holders have also increased. Table 2 shows, the distribution of engineering degree and diploma holders have changed over the period 1971-91. Branchwise out-turns are shown in Table 3.

Through the present education facilities roughly 650 engineering degree holders and 800 engineering diploma holders are adde annually to the (existing) stock of engineering and technology manpower.

Engineering Manpower Stock

The supply base of engineering manpower is fairly large. Due to the increasing supply, the stock of engineering manpower has registered impressive growth as shown in Table 4.The actual stock of engineering degree holders (including those self employed and unemployed) in 1990-91 is around 9,200 and diploma holders (including self employed and unemployed) is around 14,500. In core engineering branches like civil, mechanical, electrical, the availability of both degree and diploma holders is quite sizeable as can be seen from Table 4.

A rough comparison of the growth of index of industrial development of Assam vis-a-vis India is shown in Table 5.

From the above, it is clear that the industrial development in this state has not been of the order of growth of engineering manpower (Table 6).

Deployment of Technical Manpower

Having considered the availability of engineering and technology personnel, it is perhaps useful to examine their deployment in various activities and sectors. Employment of engineering and technology personnel in different sectors by different activities are presented in Tables 7–12.

Table 7 - Employment of engineering / technology personnel by level and by sectors in 1990-91.

Level of Education	Sector / Employment (number)						
	Central Govt.	State Govt.	Central Public sector under taking	State Public sector under taking	Co-op. Local bodies	Pvt. Sector	Total
Ph.D.	11	24	-	3	1	-	39
Post Graduate	89	168	146	9	15	88	515
Graduate	443	2894	2008	1068	71	838	7322
Diploma	1456	5141	1648	1970	239	1033	11487
Total	**1999**	**8227**	**3802**	**3050**	**326**	**1959**	**19363**

Source: IASST Report 1995 , Guwahati.

Table 1 - Intake capacity and Indices of its growth of Intake capacity of E&T Course.

Year	Intake capacity (number) Level		Indices Level	
	Graduate	Diploma Holder	Graduate	Diploma holder
1971	330	765	100	100
1981	520	1114	158	146
1991	655	1140	198	149

Source : NTMIS, Guwahati Branch.

Out-turn of Graduates and Diploma Holders

Table 2 - Growth Profile and Indices of Out-Turn of E&T Manpower.

Year	Growth Profile of out-turn Level		Growth of Indices of out-turn Level	
	Graduate	Diploma Holder	Graduate	Diploma holder
1971	293	208	100	100
1981	349	623	117	300
1991	661 (including AMIE graduates)	834	222	401

Source : NTMIS, Guwahati Branch, IASST, Guwahati,

Table 3 - number of engineering degree / diploma out-turn branch wise.

Numbers

Branch	1980-81		1985-86		1990-91	
	Degree	Diploma	Degree	Diploma	Degree	Diploma
Civil	134	375	218	343	236	378
Mechanical	110	94	144	141	194	98
Electrical	86	132	77	155	110	130
Chemical	2	-	19	17	20	14
Electronics & Telecom	17	-	18	-	86	39
Computer-Science	-	-	-	-	15	23
Others	-	22	-	73	-	152
Total	**349**	**623**	**476**	**729**	**661**	**834**

Source : NTMIS, Guwahati Branch

Table 4- Stock of engineering / technology manpower by branches :

Branch	1970-71		1980-81		1990-91	
	Degree	Diploma	Degree	Diploma	Degree	Diploma
Civil	1101 (47.0)	2178 (55.0)	1698 (42.56)	3883 (59.43)	3172 (39.68)	6831 (54.49)
Mechanical	562 (24.0)	387 (10 0)	1061 (26.60)	823 (12.66)	2193 (27.44)	1869 (14.91)
Electrical	515 (22.0)	348 (9.0)	724 (18.14)	879 (13.45)	1392 (17.42)	1990 (15.87)
Chemical	47 (2.0)	39 (1.01)	184 (4.61)	36 (0.55)	344 (4.30)	184 (1.47)
Electronics & Telecom	18 (0.8)	96 (2.48)	66 (1.65)	89 (1.36)	300 (3.75)	194 (1.55)
Computer Science	-	-	15 (0.37)	-	159 (1.99)	-
Arch.	8 (0.3)	24 (0.62)	46 (1.15)	22 (.337)	96 (1.20)	179 (1.43)
Others	92 (3.9)	848 (21.9)	196 (4.9)	802 (12.27)	337 (4.22)	1290 (10.29)
Total	**2343 (100.0)**	**3870 (100.0)**	**3990 (100.0)**	**6534 (100.0)**	**7993 (100.0)**	**12537 (100.0)**

Figures in bracket represent percentages.

Table 5- Index of Industrial Production

Year	Assam Base 1970=100	Year	India Base 1980-81=100
1970	103.57	1981-82	109.3
1991	190 (110.5*)	1990-91	212.6

Source : Economic Survey of India (1994-95), Statistical Hand Book, Assam, 1993.
* Base 1980-81 = 100

The average Annual Growth Rate of Industrial Production. Assam : 3.08
India : 7.67

Table 6- Growth rate of engineers of Assam

Year	Total Engineers	Growth Rate (Percentage) (with 1971 as base)
1971	6213	--
1991	23669*	6.92

* (including 1078 unemployeed degree engineers and 2782 unemployed diploma engineers).
Source IASSI Report 1995 , Guwahati, Assam

Table 8—Employment of engineers by level and by activity in 1990-91

Level	Activity/employment (number)							
	Mining & Quarrying	Manufacturing & Processing	Construction	Electricity, Gas & Water Supply	Transport Communi-cation	Teaching Research services	Others	Total
Ph D	0	0	1	0	0	37	1	39
Post-Graduate Degree/ Diploma	87	99	27	5	16	152	129	515
Graduate	1087	1573	1168	833	282	221	2158	7322
Diploma Holder	831	1555	2599	1929	1011	157	3405	11487
Total	**2005 (10.35)**	**3227 (16.67)**	**3795 (19.60)**	**2767 (14.29)**	**1309 (6.76)**	**567 (2.93)**	**5693 (29.40)**	**19363 (100.0)**

Source: IASST Report 1995 , Guwahati, Assam.

Table 9—Employment of engineers by branch and by sector in 1990-91

Branch	Public sector (Number)					Private sector (Number)					Total (Number)				
	Ph.D	P.G.	Degree	Dip.	Total	Ph.D	P.G.	Degree	Dip.	Total	Ph.D	P.G.	Degree	Dip.	Total
Civil	7	127	2810	5522	8466	-	10	93	79	182	7	137	2903	5601	8648
Mechanical	14	72	1751	2014	3851	-	28	280	286	594	14	100	2031	2300	4445
Chemical	6	49	414	171	640	-	-	29	20	49	6	49	443	191	689
Electrical	7	47	963	1846	2863	-	17	170	169	356	7	64	1133	2015	3219
Electronics & Telecommunication	0	35	224	116	375	-	5	3	15	23	-	40	227	131	398
Computer	3	24	13	51	91	-	11	111	180	302	3	35	124	231	393
Instrumentation	0	15	31	22	68	-	-	3	9	12	-	15	34	31	80
Mining	0	0	11	7	18	-	2	7	27	36	-	-	2	18	34	54
Metallurgy	0	-	16	1	17	-	2	19	9	30	-	2	35	10	47
Architecture	-	4	13	67	84	-	3	31	34	68	-	7	44	101	152
Agriculture	-	7	41	67	115	-	-	-	-	-	-	7	41	67	115
Others	2	47	197	570	816	-	10	92	205	307	2	57	289	775	1123
Total	**39**	**427**	**6484**	**10454**	**17404**	**-**	**88**	**838**	**1033**	**1959**	**39**	**515**	**7322**	**11487**	**19363**
	(.0022)	**(2.45)**	**(37.26)**	**(60.07)**	**(100.00)**	**(-)**	**(4.49)**	**(42.78)**	**(52.73)**	**(100.00)**	**(.002)**	**(02.66)**	**(37.82)**	**(59.33)**	**(100.00)**

Source : IASST Report 1995 , Guwahati, Assam.

Table 10—Employment of engineers by branch and by main activity in 1990-91

	Activity / employment (number)							
	Mining and Quarrying	Manufacturing and Processing	Construction	Electricity, Gas & Water Supply	Transport & Commu-nication	Teaching and Research	Others	Total
Civil	257	313	3315	346	440	153	3824	8648
Mechanical	1109	966	299	941	413	146	571	4445
Chemical	108	406	-	-	-	39	130	689
Electrical	318	574	113	1466	311	104	303	3219
Electronics & Telecommunication	93	92	-	1	127	30	55	398
Computer	4	11	3	-	1	29	345	393
Architecture	-	-	40	3	7	-	102	152
Others	116	865	25	4	10	66	333	1419
Total	**2005**	**3227**	**3795**	**2767**	**1309**	**567**	**5693**	**19363**

Source : IASST Report 1995 , Guwahati, Assam.

Table 11—Employment of graduate engineers by branch and by sector in 1990-91

Branch	Sector / Employment (Number)								
	Central Govt	State Govt	Central Public sector under-taking	State Public sector under -taking	Local Bodies	Co-operative Societies	Pvt. Sector	Others	Total
Civil	180	2339	182	222	13	1	103	7	3047
Mechanical	117	422	954	336	-	-	308	7	2144
Chemical	20	49	345	51	-	2	29	2	498
Electrical	92	139	349	404	3	1	187	29	1204
Electronics & Telecommunication	91	19	129	17	3	-	8	-	267
Computer	5	12	17	1	5	-	122	-	162
Instrumentation	-	-	42	-	3	-	3	1	49
Mining	1	2	6	1	-	-	9	1	20
Metallurgy	2	1	9	3	-	-	21	1	37
Architecture	2	7	2	6	-	-	34	-	51
Agriculture	2	30	9	7	-	-	-	-	48
Others	31	66	110	32	4	2	102	1	348
Total	**544**	**3086**	**2154**	**1080**	**31**	**6**	**926**	**49**	**7876**
	(6.91)	**(39.18)**	**(27.35)**	**(13.71)**	**(.004)**	**(.0008)**	**(11.76)**	**(.0062)**	**(100.00)**

Table 12—Employment of diploma holder engineers by branch and by sector in 1990-91

Branch	Sector / Employment (Number)								
	Central Govt.	State Govt.	Central Public sector under-taking	State Public sector under -taking	Local Bodies	Co-operative Societies	Pvt. Sector	Others	Total
Civil	720	4098	404	259	12	1	28	79	5601
Mechanical	251	490	566	664	1	3	39	286	2300
Chemical	2	33	91	45	-	-	-	20	191
Electrical	340	179	299	915	1	6	106	169	2015
Electronics & Telecommunication	56	7	53	-	-	-	-	15	131
Computer	6	4	32	2	7	-	-	180	231
Instrumentation	5	1	11	5	-	-	-	9	31
Mining	-	-	7	-	-	-	-	27	34
Metallurgy	-	-	1	-	-	-	-	9	10
Architecture	4	57	-	6	-	-	-	34	101
Agriculture	1	45	-	21	-	-	-	-	67
Others	71	227	184	53	2	33	-	205	775
Total	**1456**	**5141**	**1648**	**1970**	**23**	**43**	**173**	**1033**	**11487**
	(12.68)	**(44.76)**	**(14.35)**	**(17.15)**	**(.002)**	**(.004)**	**(1.51)**	**(9.00)**	**(100.00)**

Table 10 clearly indicates that engineering degree and diploma holders were mostly performing technical functions in their respective areas of taining. For example, in construction, out of 3795 engineers 3315 (87.4%) are civil engineers. Also 299 (7.9%) and 113(3%) mechanical and electrical engineers are needed for support in construction. Similarly, in electricity, gas and water supply (E.G & W), 1466 (53%) are electrical engineers and941 (34%) and 346 (12.5%) are respectively mechanical and civil engineers, who are required to perform other works in E.G.&W. Thus it is clear that most of the engineers are performing their technical function though they are employed in different activities such as construction, E.G.&W etc.etc.

It may be seen from the earlier data that, out of total stock of engineering graduates of 9178 roughly 88% were employed and rest can be assumed to be unemployed or not seeking employment; those employed including self employed (whose number is 226) are largely confined to construction, consultancy, manufacturing and repairing activities. Out of total stock of engineering diploma holders (14,491), roughly 81% (including self employed, whose number is roughly 222) were employed and rest can be taken to be unemployed or not seeking employment i.e., not in the labour force. Out of the total employed engineering personnel the overwhelming proportion i.e., 89.9% are in the public sector, private sector employing only 10.1%. In the public sector, the state Govt. departments employ the highest proportion of 42.5%, followed, in order, by the public sector undertakings and the central government departments. The central PSUs employ higher number of engineers than the state government PSUs. By activity, 19.6% were employed in construction and 16.7% were employed in manufacturing, while teaching and research got the minimum share of engineers.Eighty seven percent of civil engineers were employed in construction and 53% of electricalengineers were employed in utilities (electricity, gas and water supply). Thirty six percent of the graduates and higher degree holder engineers were employed in public sector and mere 5% were employed in private sector. More than 88% of post-graduate and degree engineers were employed in public sector undertaking and state/central government departments. It is also observed that state government employed most of the civil engineers, while industry employed most of the mechanical and electrical engineers.

Conclusions

The technical manpower resources available, their deployment against the status of industrial / economic development in Assam have been highlighted. It appears that the increase in technical manpower base has not made an appreciable impact on Assam's industrial and economic development. Hence there is a need to make indepth studies on the impact of technical manpower on the industrial sector by going into the details of their employment characteristics, the skills requirement of the industry and more specifically surplus and shortage categories etc. Such studies will be helpful in the planning of education, employment and development planning.

Acknowledgement

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Indicators of Performance Evaluation for Public Funded R&D

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An attempt is made to identify input-output indicators for evaluation of performance in terms of effectiveness measures. This is done essentially because time measures of input and output are hard to come by in research, since the benefits of research are often intangible and difficult to measure at least in the short to medium terms. Indicators of performance vis-a-vis input-output measures are developed for evaluation purposes.

1. Introduction

As funds for S&T become scarce, the need for measuring outputs of science becomes more important. Even as the methodology of S&T indicator is being developed[1], governments and other organs of public policy are beginning to take an interest in the measurement of science and the use of qualitative analysis for policy in science[2]. S&T Indicators are increasingly appearing in debates as S&T policy and in CSIR also efforts have been recently made to formulate an index of research performance[3]. Since it is difficult to correlate S&T economical inputs with S&T economic outputs, science accordingly is being thought of in terms of processes, products, publications, patent fees, production royalties, process/product consultancies, professional training etc. Indicators provide indirect information as the phenomenon or events to which they are applied. Indicators thus help to index immeasurable items to a certain extent. Science,Technology and innovation are mostly, abstract concepts that cannot be measured directly and so indicators are being increasingly used in a manner so as to reflect the pattern of research performance

The Organisation for Economic Corporation and Development (OECD) has played a crucial role in the development of S&T indicators and has set the pattern for comparable measures and S&T indicators through Frascati Manual[4]. Thus indicators help to make indirect input-output evaluations in S&T serving the important purposes of parity setting, policy planning and fund allocations.

The data on S&T input are presented in terms of money and people. However, this data have to be indexed in terms of funds and manpower available inputs for R&D taking into account their extent, nature and quantum. S&T output is reckoned under bibliometrics, patents, capital achievements for utilizing know- how consultancies and royalties from innovations / new product transfers to industries etc. These are the indicators of knowledge/research contribution effectiveness and applied R&D, application of technology effectiveness

As yet another parameter could be under educational contribution in the form of Ph.Ds or such other expertise transfers through training and workshops[5].

Though indicators are usually developed for national level, with statistical comparisons the same logic can be applied for analytical purposes of inter-laboratory comparisons or intra- labotatory comparisons (R&D group-wise evaluation). This paper dwells on a case study of performance evaluation carried out in a national laboratory for inter-group comparisons based on input- output indicators.

2. Illustration

Let us take an R&D Laboratory under a Central Government body like CSIR, which receives funds from its parent body. It may also receive funds from other agencies such as government departments, Industry (both public and private sector) and foreign

agencies. The Laboratory has multidisciplinary involvement and carries out both pure and applied research. The input-output of the laboratory is schematically Fig 1.

3. Methodology

3.1. Input Indicators

Funds for the R&D process are essentially taken as the input indicators. Funds come under different categories like general, special funding from Parent body and other government departments, grant-in-aid from various sources, funds from industry in the public and private sectors etc. In the case of government funds, those provided for staff salary, research consumable, capital equipment and research applications are considered as being directly available as inputs to R&D process. As for grant-in-aid funds, a percentage(10%) is set apart as lab- reserves, in the case under study. Hence the remaining (90%) alone is reckoned. In the case of industrially sponsored funds, one-third is usually set apart for intellectual fee distributions among scientific personnel and hence two-thirds of such funds thus qualify as R&D input.

3.2. Output Indicators

As already mentioned output is categorized directly under applied R&D (a) application contribution and (b) knowledge effectiveness. The third component of educational contribution is not considered in this analysis. However measures can be developed for the same as well

3.2.1. Application Contribution

Technologies when transferred give rise to commercialization income in the form of royalty fees for patent/know-how utilization. Process consultancy fees is another form of output incomes. These are to be considered as direct measures of output. Intellectual fee component of sponsored funds is a rather indirect measure of application potential since this is given in recognition of the expertise value as relevant to applied research. On a similar line of argument funds from other sources is also reflective of application oriented expertise development, since in the absence of any utility value vis-a-vis application of research results, no agency or industry would be providing funding support (like grant-in-aid funds). However depending on the nature of the funding source, a certain percentage of grant- in-aid funds can also be taken as an input indicator. For funds from departmental agencies like DST/DBT etc., 10% credit can be given whereas for industrially sourced aid, a 20% credit can be accorded (i.e. 20 % of grant-in-aid from industry sources can be taken as an output indicator on the same pattern as 33% credit is given for sponsorship funds industry). This percentage can thus worked out at levels ranging from 10-30% depending on the nature of the funding levels. For example, if relatively large-scale funds are available as grants from a multinational giant, a 30% credit can perhaps be accorded. However in the case under study let us assume no such situations have arisen. Nevertheless for purposes of generalization, such provisions have to be made in the model

3.2.2. Knowledge Contribution

This is measured in terms of publication in refereed journals. Weightages with citation indices and journal impact factors are possible. In the case of cross-area comparisons, there are not reliable relative measures particularly since journal impact factors very widely for the best journals in different areas. Citation units are mere reliable, yet they are available after reasonable time delays. The spectral data stabilize over varying periods of time thus rendering the analysis skewed. Nevertheless they are used in connection with reviews, citations are a useful measure. While citations have their limitations, they can be statistically compensated and controlled so that they become relevant indicators of knowledge contribution qualitatively and quantitatively[6]. In the absence of citation data the actual number of publication is a most genuine measure since there is a direct correlation between national shares of publication output and citation units particularly in respect of SCI journals[7].

Citation data requires careful and balanced interpretation to be most effective in S&T analysis. These data have their inherent limitations since their importance wanes at higher levels of data aggregation. For example if one wants comparisons of groups or institutions, aggregated at next level citation data can be used to indicate the journal impact features[8,9]. Taking into account the above in this analysis actual number of publications in journals is taken as indication of knowledge aspect. A higher weightage factor

Disciplinary/ group	A	B	C	D	E	F	G	H	I	J

Inputs

Parent body (Salary IR+Res.exp)	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10
GIA	b1	b2	b3	b4	b5	b6	b7	b8	b9	b10
Sponsorship	c1	c2	c3	c4	c5	c6	c7	c8	c9	c10
Spl. funds	d1	d2	d3	d4	d5	d6	d7	d8	d9	d10

Total Input (I) $\Sigma a1\, \Sigma a2 \ldots\ldots \Sigma ai + \Sigma bi + 2/3ci$

Outputs :

		A	B	C	D	E	F	G	H	I	J
a)Hard Output (H)											
Int.Fee		m1	m2	m3							m10
ECF credit		n1	n2	n3							n10
Consultancy		p1	p2	p3							p10
Royalty /percent in capital investment		q1	q3	q3.....							q10
b)Soft output (S											
Publication	I * N *	r1	r2	r3							r10
Patents	I N	t1	t2	t3							t10
Software& Algorithm		v1	v2	v3							v10

Thus H (indicator for hard output related to applied research or application contribution)

$$= \Sigma mi + ni + pi + qi$$

where ni = kj.bi (kj ranging from 0.1 to 0.25 depending upon funding source see text)
mi = 1/3 of Ci
* I : International ;* N : National

Fig 1—Schematic of the input-output representation

of 2 is given for international publications (in SCI type journals) since by and large international publications are more prized as compared to national publications. To a certain extent, apart from the number of publications, processes developed, patents filed, and prestigious awards won can also be reckoned as embodied knowledge and hence part of output under knowledge contribution. When processes and patents are utilized, they form part of technological contribution or research application component reflected through indicators in the forms of revenues generated (royalties, patent fees, consultancies) or capital investment in industry as part of commercialization of research findings (A certain percent of the capital investment nucleated for process commercialization comparable in value with other forms of revenues generated like royalty, intellectual equity / fees etc., should be worked out to be connoted as an indicator of applied research output). Appropriate weightages should be given to the above indicators of knowledge like papers, algorithms, processes, patents etc. In the case of papers a weightage of 2 for international publication (SCI journals) and 1 for national publications (listed in the current contents) is made. In the case of process/patents a weightage of 1.5 is given, with a higher weightage of 2 being given for international patents. Processes developed but not patented are counted separately from process or other components of knowledge for which patents are filed. Processes that are not patented are also counted since some intellectual effort has gone into developing a process with some potential use for economic sector, but which is not yet so utilized, nor could be patented in the presented form being largely a product of an adaptation or a 'tinkering' or incremental effort[10-12]. A few of such processes can also be given a weightage of higher than unity depending on a assessment of the worth of the same by some departmental committee of peers or experts. Peer reviews can also be used as a measure of evaluating quality of publications and this coupled with citation data provides a superior measure of quality. However,in the case under study, a weightage of 1 is given for processes/algorithms, (a weightage of 2 or more can be given for internationally filed patents) and a weightage of 1.5 for a patent filed in the country. Incidentally there were no international patents during the period under study. (With the greater focus in CSIR on application of knowledge, patents can be given a higher weightage than the above. However, there must be uniformity for purposes of inter-lab comparisons).

4. Analysis

Following the methodology outlined above and giving some arbitrary numbers for Inputs and Outputs as shown in Table 1, contribution of application knowledge and composite/ efficiency has been worked out for each group and tabulated in Table 1 It may be noted that, I is the total input indicators

H is the hard output (application competency) indicator. A is the indicator for application effectiveness.(i.e., $H/I\,n$ percent). S' is the normalized indicator for knowledge component derived from S such

Table 1—Input-output parameters

R&D groups	I	H	$\frac{H}{I} \times 100 = A$	$S' = \frac{S}{5}$	$\bar{S} = \frac{S'}{I} \times 100$	$E = A + \bar{S}$
A	85	14	16	19	2.24	18.24
B	35	2	6	19	5.43	11.43
C	70	6	8	38	5.43	13.43
D	130	2	2	33	2.48	4.48
E	41	9	22	26	6.34	28.34
F	44	9	20	15	3.14	23.14
G	79	3	4	40	5.06	9.06
H	96	–	0	9	0.1	0.1
I	24	0.8	3	24	10	13
J	42	2	4	23	5.48	9.48

that e $\sum_{1=1}^{n} H_i \approx \sum_{i=1}^{n} S'_i$ (i.e. $\sum H_i$ is comparable numerically to $\sum S'_i$). $\bar{S}$ is the normalized Indicator for knowledge effectiveness

One can now rank the group with medium range (50 percentile). Thus from the illustration given in Fig. 1 only three groups (E,F&A) come under application and composite effectiveness, while five groups (B,C,E,I & J) come under knowledge effectiveness (Table 2). This type of ranking has to be done for a minimum of three years. A comparison of such an analysis on subsequent years would also give changes in the ranking of various R&D groups over the previous years. Thus this exercise would help the laboratory management to take note of the performances of various R&D groups in the laboratory and to take necessary corrective measures for low performing groups.

A is a measure of application effectiveness ; $\bar{S}$ is a measure knowledge effectiveness ; E is a measure of composite effectiveness. (This gives equal weightage to the Application and knowledge contribution in the output component) ; A, $\bar{S}$ and E are effectiveness measures in that they correlate with input and output.

5. Limitations of the Model

The above model has certain limitations ; it does not take into account history of infrastructural development among the R&D units being compared. For purposes of analysis only the input and output indicators are considered over the period under review (say Annual, Biannual - Three years or Five years) prior to this period. The status of infrastructural inputs and level of performance could be vastly varying for the different groups under comparisons..If the comparison is among different labs situated in geographically separate regions, locality specific/advantage/or 'disadvantage' factors might also have played a role in influencing input-output. The model does not take into account this also.

Thus the model can be made more comprehensive by adding 'skew' factors due to (a) Status of infrastructural development that can have an influence on inputs and outputs (b) Status of industrial development or such other location specific factors that would possibly influence input-output indicators.

The model presented in this paper is exclusively focused on knowledge contribution and application potential aspects for indicating basic research and applied or technology component. It does not indicate any other aspects of relevance in the scientific and industrial research context in the country like socioeconomic contribution or training effectiveness. Rural development and other social issues have formed part of the R&D platform in the past and a lot of extension related activities are based on this. A social utility function can be associated with such extension work, which is not considered under the model. Further, extramural research in our S&T institutions leading to trained doctoral personnel is not also considered as part of trained man power output. The model can be suitably modified by taking into account the Ph.D out turn factor. However, the 'complexities' due to the above considerations are not presently considered as part of the model under discussion. It can nevertheless form part of a more 'expanded' version of the same model.

Table 2 — Fifty percentage ranking

FOR A	FOR S	FOR E
E	I	E
F	J	F
A	B	A
	EC	

6. Concluding Comments

A model has been presented as an attempt at quantifying input- output related statistics by developing suitable indicators for performance evaluation and comparison among R&D groups within a public funded laboratory or between such individual laboratories. The main criteria used for the evaluation are knowledge effectiveness and application effectiveness

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Neutron Radiography and Transfer Imaging Technique for Qualification of Space Components*

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Some of the sophisticated components like pyrotechnic devices used in the launch vehicles and saatellites pose problems to screen them due to their typical configuration in which the explosive charges are encased in heavy metallic enclosures. A special technique tried for the first time in India for the inspection of space components has been reported employing neutron radiography using accelerator based neutron generator and transfer imaging method.

Introduction

SHAR Centre is the premier Rocket Launch Centre of India. In addition to the launching activities, the Centre has other facilities for manufacture of huge solid rocket motors, ground testing, launch vehicle assembly, tracking, etc. Almost all the components and sub systems that go into the launch vehicle or satellite are subjected to stringent quality control programme since they perform only once, unlike other engineering components. Various non-destructive testing (NDT) methods like high energy radiography, real time radiography, ultrasonic testing, magnetic particle testing, infrared thermography testing, acoustic emission testing etc.are being employed to screen the space components. Some of the sophisticated components like pyrotechnic devices used in the launch vehicles and satellites initially posed inspection problems. The difficulty arose mainly due to their typical configuration in which the explosive charges are encased in heavy metallic enclosures. Most of the conventional methods are not amenable and the inspection of these critical devices is possible only by thermal neutron radiography (NR). A special technique has been developed at the NDT facility of SHAR Centre using accelerator based neutron generator and transfer imaging methods and the inspection impasse has thus been solved. This technique based on accelerator is the first of its kind to be ever used in our country for the qualification of critical components like
pyro devices.

*The work reported is carried out by the author amd his team in the Solid Propellant Space Booster Plant, SHAR Centre, Sriharikota -524124.

Pyro Devices and Neutron Radiography

Pyrotechnic devices are sophisticated systems which offer a self-contained energy source that possess the highest work potential in smallest volume and minimum weight. In space programme, they are used in launch vehicle as well as satellites for performing various functions like ignition, stage separation, flight termination, space-craft deployment etc. Figure 1 shows typical application of pyro devices in PSLV launch vehicle. As the pyro devices make use of explosive energy to perform various functions, their construction has a hydrogenous explosive material encased in a metallic enclosure of stainless steel or aluminium. Figure 2 shows a typical pyro device. Any NDT method adopted must be able to inspect the explosive charge inside the metallic enclosure in order to ensure its performance. Normally X or gamma radiographic inspection can reveal only the hardware details while the interior explosive material details are not resolved. To solve this inspection impasse, neutron radiography offers the best solution. The attenuation of neutrons by materials is entirely different from that of X or gamma rays. While X or gamma rays interact with orbital electrons of elements , neutrons interact directly with nucleus. This explains the phenomenon that the attenuation of X-rays increases with atomic number of elements while the neutron attenuation is

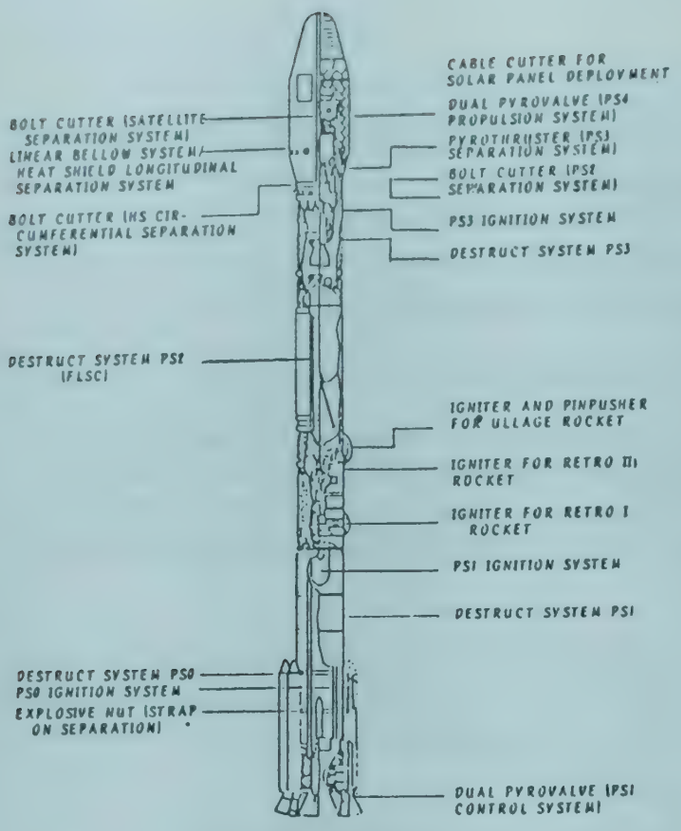


Fig.1–Applications of pyro devices in PSLV launch vehicles

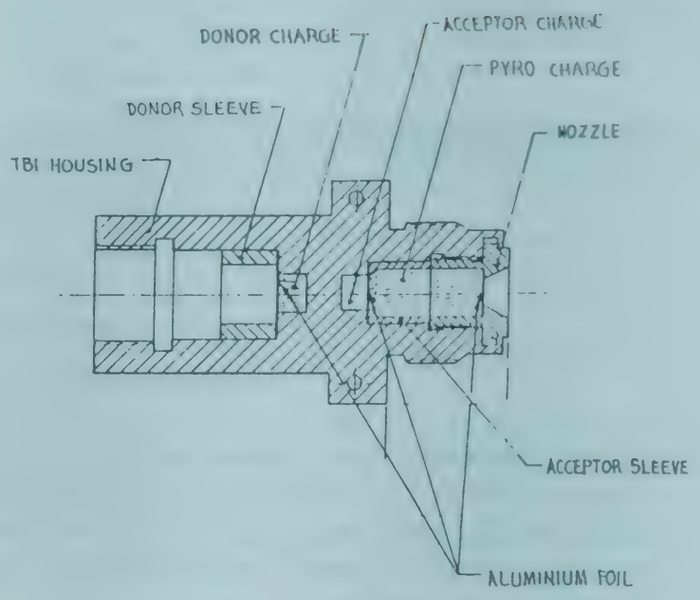


Fig.2–Typical pyro device (TBI assembly)

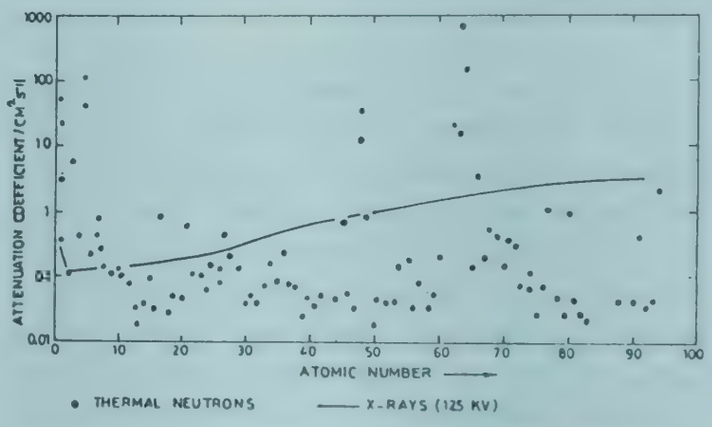


Fig.3–Neutron and X-ray mass attenuation coefficients for the elements

random as shown in Fig.3 . As seen from the figure, neutron attenuation is generally high for low 'Z' (atomic number) materials and low for high 'Z' materials. This basic difference makes neutrons more advantageous than X or gamma rays and ideally suited for our situation where low 'Z' explosives are encased in high 'Z' metals. Typical defects encountered in pyro devices are absence of explosive charge, interface gap, moisture ingression, voids, misalignment in the explosive, which can cause failure of the components and eventually the whole mission, if left undetected.

Neutron Facility at SHAR Centre

During initial days of qualification, these pyro devices were taken to BARC and inspected[by using APSARA nuclear reactor source. Because of the reactor source, the direct imaging technique was adopted. However, in the later days, it has become almost impracticable to transport these pyro devices and inspect them at the reactor facilities because of their explosive nature. Hence ISRO started looking for alternative in-house source for neutron inspection. During that time in mid 80's , SHAR centre was engaged in the augmentation of facilities to cater to PSLV needs. A 15 MeV linear accelerator was proposed for the radiographic inspection of huge PSLV solid motors. An extensive study has been undertaken by us to combine this X-ray facility which can also be used for the generation of thermal neutrons. Based on the possibility that neutrons can be generated from high energy X-rays by (x,n) reaction using suitable materials, it was decided to procure a neutron generator along with the proposed 15 MeV machine. Accordingly detailed specifications were drafted to get a 15 MeV linear accelerator along with a neutron target assembly to serve as a two-in-one machine, viz., a high energy X-ray machine for radiography of huge solid rocket motors and a neutron source for neutron radiography inspection of pyro devices. After prolonged efforts, a 15 MeV high energy X-ray machine along with neutron generator was finally installed in 1987. This resulted in huge savings for the Department.

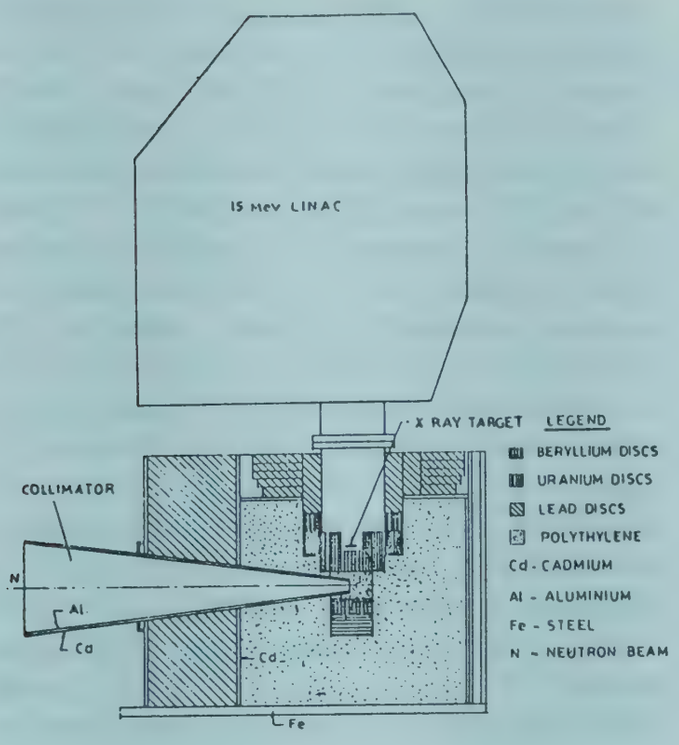


Fig.4–Neutron generator assembly (accelerator based)

15 MeV LINAC As Neutron Source

The neutron target consists of target core, moderator and shielding assembly. The target core is the centrally mounted aluminium can containing uranium, and beryllium rings. The core has a cut-out to allow entry of collimator into a specially machined piece of polyethylene. The target core is surrounded by polyethylene moderator assembly and shielding materials to shield neutrons and X-rays in other directions (Fig.4). The X-rays generated at the tungsten target impinge on U-Be assembly and generate neutrons according to the nuclear reaction:

$$_4Be^9 \xrightarrow{\text{X-rays}} {}_4Be^8 + {}_0n^1$$

$$_{92}U^{238} \xrightarrow{\text{X-rays}} {}_{92}U^{237} + {}_0n^1$$

The yield from the photo neutron reaction of uranium is higher in case of gamma energies more than 9 MeV while beryllium is good producer of neutrons in the lower gamma energy as its threshold energy is very low,around 1.66 MeV. The yield from the uranium target is considerably higher than the yield from beryllium target at photon energies of 15 MeV and higher. Further the neutron yield from uranium fission also contributes towards the flux increase. These neutron are moderated by the polyethylene blocks and the thermal neutron beam is drawn out from the collimator.

Measurement of Neutron Flux

Neutron flux values were measured with full output at the exit plane of the collimator by gold foil activation and by subsequent count of the 411 KeV gamma emitted from Au-198. Thirteen numbers of gold foils of 10 mm diameter were irradiated and the flux measured indicated a uniform field of 1.1 x 10^6 n/cm^2/s with ± 10% variations and the cadmium ratio obtained is 5 indicating good thermalization of the beam. The measured value of beam characteristics are:

Thermal Neutron Flux	1.1 x 10^6 n/cm^2/s
Cadmium Ratio	5 (gold foil measurements)
L/D Ratio of Collimator	16
Type of Collimator	Divergent type with truncated pyramid, square cross section
Image Plane Size	225 mm x 225 mm

The neutron to gamma ratio as measured was found falling short of the minimum required value of 1 x 10^5 n/cm^2/s/mR. This was expected due to very intense beam of X-rays associated with this type of accelerators.

Imaging Methods

Photographic emulsions are most commonly used in any radiography for image recording. Neutrons will pass through the film emulsion without much interaction. Hence neutron is necessarily converted into more effective form of secondary radiations such as electrons, alpha particles, or photons by interaction with suitable materials called converters. The secondary radiation may be prompt or delayed and yield depends upon the flux of neutrons, number of converter screen atoms and the macroscopic absorption cross section. Converters are used as back screens in neutron radiography to avoid self absorption. Two approaches are used in imaging. In direct imaging method prompt radiation is used in image formation in which the object, converter screen and recorder are simultaneously exposed in the neutron beam. In the transfer imaging method the delayed radiation is used in which the converter screen and object alone are exposed and the exposed converter with built-up

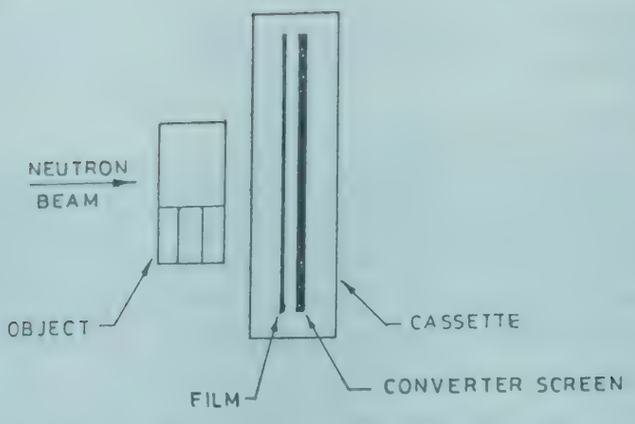


Fig.5–Direct exposure method

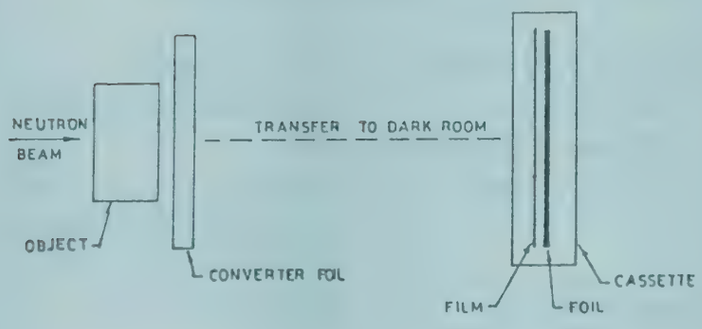


Fig.6–Transfer exposure method

activity is taken to darkroom for film exposure(auto radiography). The two techniques are illustrated in Figs 5 and 6. The most widely used converter screen in direct exposure method is gadolinium screen of 25 micron thickness, while commonly used converter screen materials in transfer method are indium and dysprosium. The advantage of transfer method is its insensitivity to gamma radiation in the neutron beam and hence it has been mostly applied in the inspection of radioactive components.

Initial measurements of beam parameters indicated high gamma intensity in the beam thus affecting the image contrast in the direct exposure method. In order to implement the direct exposure method various methods of reducing gamma intensity of the beam were attempted. Collimation of the beam size with lead blocks to reduce the scattered gamma and the introduction of bismuth filter into the beam which selectively absorbs gamma more than thermal neutrons were tried in different combinations. All these studies and experiments resulted in only marginal improvement in the image quality due to high gamma intensity associated with this type of accelerator based machines. Hence it was decided to implement the transfer imaging method for inspection of pyro devices.

Radiographic image quality or sensitivity is generally judged by contrast and resolution and for this image quality indicators (IQIs) are used in any radiography. In case of NR, ASTM recommends the use of Beam Purity Indicator (BPI) and Sensitivity Indicator (SI) as per ASTM-E-545-1991. Although this standard is meant for use with direct imaging method, we had to resort to the same, because no standards are available for transfer technique. The cadmium wires in BPI show the unsharpness of the set up and various thicknesses of aluminium spacers in the SI help to evaluate the resolution obtained in the image.

In the initial exposure carried out, dysprosium screens of 150 micron thickness were used for a number of components. Although the transfer technique provided the required details regarding the presence of pyro charges, 'O' rings, potting compounds, it was felt that the radiographs required some more sharpness for seeing the interface details.

Image Sharpness and L/D Ratio

Three sources of unsharpeness in radiography are due to (a) geometric (b) inherent/film screen and (c) scatter. Scatter unsharpness is negligible in a good radiographic set up. Inherent or film screen unshapmess, 'U_f' mainly depends on the radiation energy forming the image and the thickness of the screen. By reducing the thickness of converter screen 'U_f' can be reduced but at the expense of increased exposure time. But in neutron radiography the main source of unsharpness is geometric in nature. Unlike in X-radiography, point sources of thermal neutrons are not available. The thermalized neutrons move in different directions in a moderator. They are extracted through a collimator of definite size. Thus neutron sources are invariably of finite size and major contributors for geometric unsharpness. Hence in order to get optimized resolution in NR, the problems of geometric unsharpness must be tackled effectively as given by the expression

Geometric Unsharpness U_g = Object size/(L/D)

Improvements in Image Quality

Neutron beams are extracted using collimators of different shape. The collimator walls are lined with neutron absorbing materials like dysprosium, cadmium, boron, etc. They are useful to get the directional beam for imaging. The geometric unsharpness of the neutron radiographic set-up is

decided by the inlet aperture(D) and length of the line portion of the collimator (L). As described above the only way of improving image sharpness is by reducing U_g which in turn is possible by altering the L/D ratio. From a study of the neutron generator it was found that there is a possibility for lengthening the cadmium lining. Accordingly, the generator assembly was dismantled and additional Cd lining was laid-up by us at SHAR Centre. Thus the additional lining not only increased the length (L), but also reduced the inlet aperture (D) and in effect increased the L/D ratio.

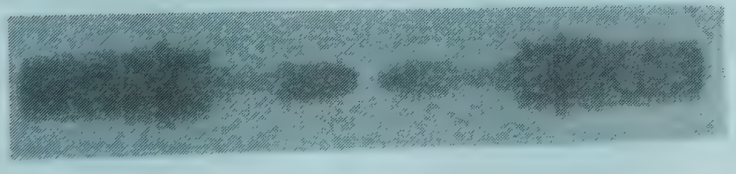
Improvement in Image Quality

After lining the collimator, neutron radiographs were taken for two typical pyro devices, IQIs of ASTM and a cadmium test piece for evaluating the image quality. Dysprosium of 0.15 mm thick was used with overnight transfer time. Considerable improvement in the sharpness of details was seen in the radiographs. The interfaces in the radiographs were seen very sharp compared to radiographs taken earlier. ASTM sensitivity indicator gave a resolution of 0.025 mm Al spacer compared to 0.05 mm spacer before modifications. These radiographs were comparable in quality to those produced by using reactor based neutron source with dysprosium screens.

Before After

THROUGH BULK-HEAD INITIATOR (TBI)

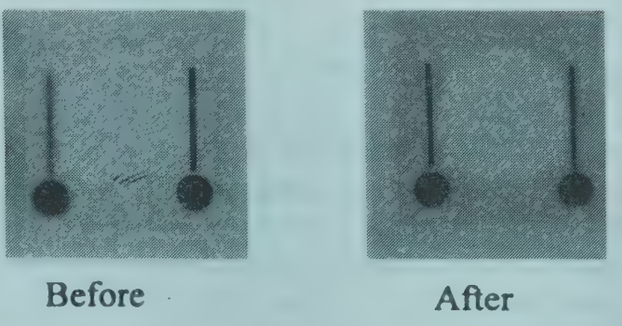
Before



After

Cable Cutter

Fig.7–Radiographs through TBI and cable cutter



Before After

BEAM PURITY INDICATOR.

Before After

SENSITIVITY INDICATO

Fig.8–Radiographs for ASTM image quality indicators

Figures 7 and 8 show the photographic reprints of radiographs taken before and after modification for two typical pyro devices, through-bulkhead initiator (TBI), cable cutter and ASTM image quality indicators.

Evolution of Transfer Imaging Method

Transfer imaging method comprised a two step process: (a) build-up of activity in the converter screen during exposure and (b) decay of activity during the transfer to the film. The build up of activity in the screen is given by the relation:

$$S = \phi \sigma N (1-e^{-\lambda T})$$

where S is the activity build-up on the screen; σ, the activation cross-section of screen material for the thermal neutrons; N, the number of atoms in the screen; T, the irradiation time; λ, the decay constant of the isotope formed; and ϕ, the neutron flux.

If the converter is transferred to a film between time 't1' and 't2' the integral activity transferred to the film is given by

$$A_{tr} = \frac{N\,\phi\left(1-e^{-\lambda T}\right)}{\lambda}\left(e^{-\lambda t1} - e^{-\lambda t2}\right)$$

where A_{tr} is the activity transferred.

The activity induced in the screen is related to mainly the activation cross section of the material, half life of the isotope, irradiation time, thickness of the converter. The most widely used converter screens in transfer method are indium and dysprosium with half lives of 54 min. and 150 min respectively. The activation cross section for dysprosium (800 barns) being higher than that of indium (157 barns), we can induce higher activity in the dysprosium screen. Further dysprosium is more amenable for handling than indium which is very flexible in nature.

Optimization of NR Parameters

Optimisation of Thickness

The optimum thickness of screen is determined by a balance between the need to convert as many neutrons as possible to secondary radiation during exposure and the need to maximise the amount of radiation reaching the recording medium during transfer. The former increases with the screen thickness, whereas the latter decreases with increasing thickness due to self absorption. Dysprosium screens of 50, 100, 125, 200 and 250 micron thicknesses were exposed and the optimum thickness was found to be around 150 microns. Further, the increasing thickness of screen will reduce the sharpness of the image.

Optimization of Exposure & Transfer Times

As mentioned earlier transfer method requires more total time than direct exposure approach. Since large number of pyro devices have to be inspected, it is desirable to reduce the total time of production of radiographs. As given by the above relations the activity build-up on the screen and activity transferred to the film are exponential phenomena and hence much advantage is not gained by longer exposure time or transfer time. Generally three half lives or overnight transfer is being followed in case of dysprosium converter screen. To reduce the total time of production of radiograph, the transfer time has to be brought down to minimum possible from over night exposure. The converter screen is exposed to longer irradiation time so that the activity is built up to higher level for shorter duration transfer to the film. Table 1 gives the details of irradiation times for one half life transfer times standardized for typical pyro components.

Table 1 –Transfer technique parameters for TBI and cable cutter components

Exp No	Screen thickness (mic)	Exp time (min.)	Transfer time	Optical density
Ex-1	150	20	Over-night	4.0
Ex-2		30	One half-life (first)	3.42
			One half-life after first	2.13
			Over night transfer for remaining activity	1.84
Ex-3		30	One half-life (first)	3.00
			One half-life after first	1.74
			Over night transfer for remaining activity	1.02

Further, after one half life transfer, the same converter can be used to transfer on to another film for second half life decay and so on and yet another radiograph can be obtained using the residual decay overnight. In this ;process a set of radiographs can be produced for detailed evaluation. The first radiograph is available for evaluation within 3 and 1/2 hours (including automatic film processing time) considerably reducing the total time involved in overnight transfer. As ISRO programmes are time-bound, any delay of process would affect the launch schedule. Even though handicapped by the accelerator source which warrants only time consuming transfer technique, the inspection time could be cut down considerably, owing to extensive experimentation and innovative improvisation of methods which were implemented by NDT Team.

Conclusion

NDT facility, SPROB established number of NDT methods to inspect solid rocket motors and related components of SLV, ASLV, PSLV projects. Particularly, in the absence of codes and standards, in-house acceptance criteria were laid down and qualified the space components for their end use. With regard to the inspection of critical pyro devices, NDT/SPROB, once again rose to the occasion in establishing a first ever accelerator based NR facility in the country and successfully qualified all the pyro devices used in the PSLV, ASLV missions and INSAT, IRS satellites which gave the excellent performance of these

components in the above missions stands testimony to the pioneering efforts of the NDT team.

Acknowledgement

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On Molten Carbonate Fuel Cells

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Molten Carbonate Fuel Cells (MCFC) are capable of delivering the DC electricity by the electrochemical reaction between any hydrogen rich carbonaceous fuel and oxygen at 650°C. A research and development programme on MCFC has been started at CECRI in 1992. The first phase of this R&D programme aims at the development of 500 watts cell stack with 1000 cm^2 geometric area electrodes and a capacity of 100 watts per cell. In the following, the progress made during the period of four years of basic studies has been reviewed. Porous nickel electrodes were prepared by loose powder sintering or slurry casting technique. Nickel - 10% *in situ* conditions served as the cathode. Electrolyte structure was fabricated by tape casting technique. The performance characteristics of MCFC single cells were described.

Introduction

Power Generation through Fuel Cells is expected to be the most attractive technology of the future, because it can generate electric power at high energy conversion efficiency[1,2]. Molten Carbonate Fuel Cell (MCFC) has been termed as the second generation fuel cell technology. They are characterized by their high temperature of operation (650°C). One of their applications would be small dispersed generator up to kw level using gaseous fuel from natural gas. The others would be central power plants in MW level using gasified coal as fuel for on site power generation.

The MCFC has the following striking features:

Power generating efficiency is as high as 50 - 55% (net thermal efficiency).

Fuel flexibility: various sources of fuels such as methanol natural gas and coal gas can be employed. The heat generated from the fuel cells can be utilized in the reformation reaction.

No effect on the environment, since no direct combustion reactions with production of NO_x are involved.

Internal reforming capability.

Can be coupled with co-generation systems.

Operational principle

A Schematic diagram of a Molten Carbonate Fuel cell is shown in Fig.1. MCFC generates electricity by transforming the energy of a chemical reaction between hydrogen, obtained from the reformation of methanol, methane, natural gas or coal gas etc; and air or oxygen at 650°C. The cell reaction occurs on two porous nickel electrodes sandwiched on both sides of a porous matrix made up of lithium aluminate containing molten carbonate as the electrolyte. The usually recommended electrolyte for MCFC is an eutectic mixture of 62 mole% Li_2CO_3 and 38 mole% K_2CO_3 (m.p 481°C). The ohmic resistance is reported to be relatively low for the above at 650°C[3].

Table 1 describes, the characteristics of the electrode materials, other components and the details of standard operating conditions of MCFC. The electrodes are supported with Ni or S.S current collectors[4].

The electrode reactions are:

At anode $H_2 + COO_3^{2-} \rightarrow H_2O + CO_2 + 2e^-$ and

$CO + COO_3^{2-} \rightarrow 2CO_2 + 2e^-$

The CO_2 produced is transferred to the cathode chamber where it is reduced along with the oxygen to form COO_3^{2-}.

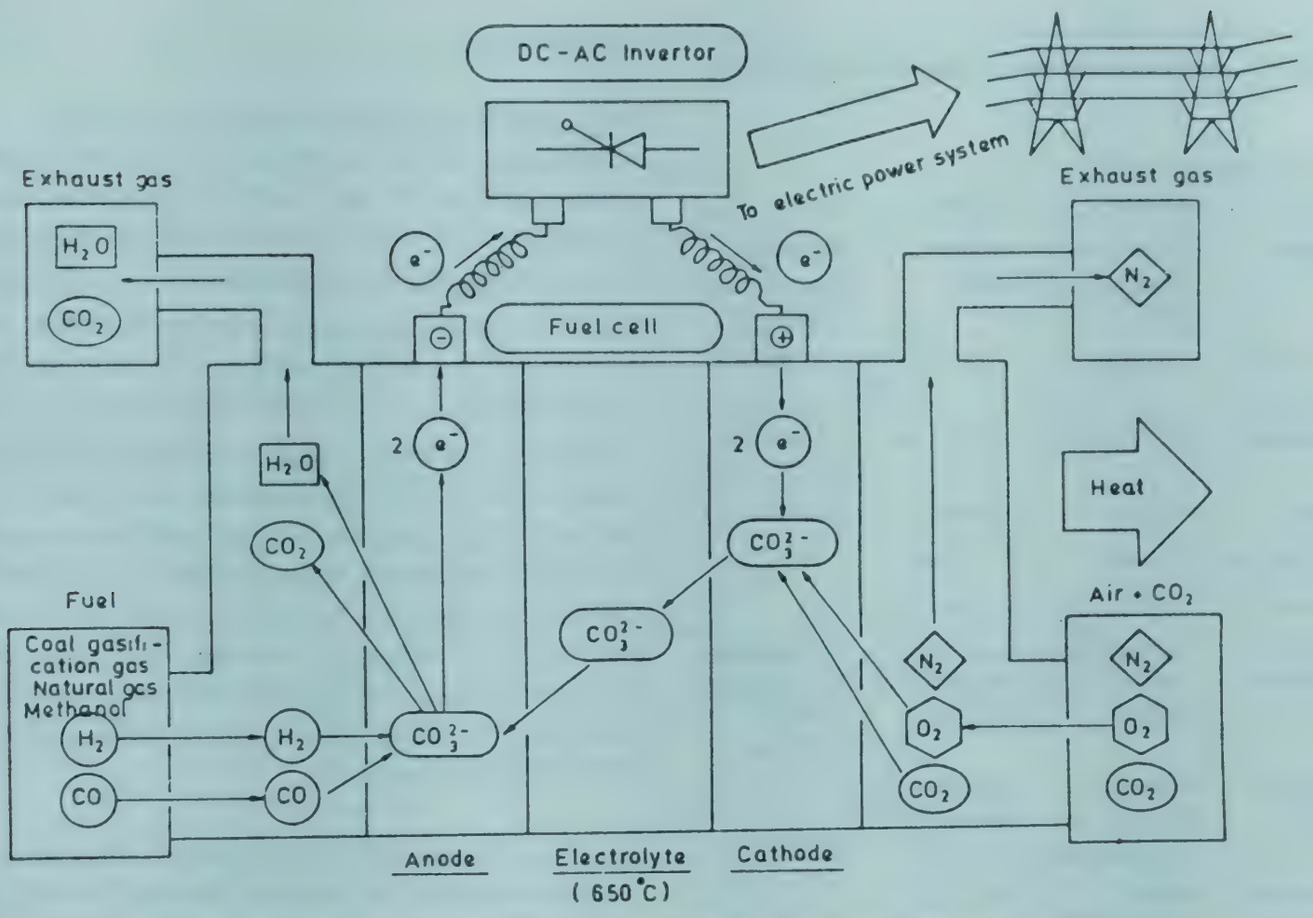

Fig 1 — Schematic of molten carbonate fuel cell power generation system

At cathode $1/2\ O_2 + CO_2 + CO_2 \rightarrow COO_3^{2-}$

The overall reaction is $H_2 + CO_2 + 1/2\ O_2 \rightarrow H_2O$ (g)

The fuels that are used in MCFC are either pure H_2. $CO + H_2$, or a mixture of gases obtained from the reformer containing mainly CO, CO_2, H_2. The CO in the latter is also subjected to the following shift reaction in the anode gas chamber:

$CO + H_2O \rightarrow 2\ CO_2 + H_2$

Thus the presence of CO_2 or cO in the fuel stream is not detrimental to the fuel cell performance. Alternatively the reforming reaction can also be allowed to occur within the fuel cell stack (Internal reforming) using the waste heat of the fuel cell at 650°C.

USA, Japan, Germany, Netherlands and few other countries are very actively pursuing R&D in a sustained fashion for the last 10 years Energy Research corporation (ERC) of USA has demonstrated 25 KW direct Internal Reforming MCFC (DFC (DFC)[5]. MC Power Corpn. USA and International Fuel Cells (IFC), USA have tested 20 KW MCFC[6]. In Japan, New Energy development of McFC. The participants are Mitsubishi Electric (30 KW units have been tested on routine basis and experimental prototypes of 25 KW have been demonstrated[7]. ECN, Netherlands has tested 10 KW MCFC[6]. Recently South Korea has also announced its McFC programme[8].

MCFC Research Programme at CECRI

Virtually no technology base has been created before 1992 in the field of MCFC in India. The need for the development of MCFC has been reported in our previous publication[9]. In 1992, a research on the development of molten carbonate fuel cells was first started as a preliminary project. Since then, the activities are mainly concentrated on the development of materials for MCFC, survey of international status on MCFC, preparation of a national document for the development of 1 kw MCFC[10] and evaluation of components under cell conditions at 650°C.

This programme exclusively aims at high level of technological research in which electrochemistry ;and materials technology play an important role. The focus points attempted in the above programme are:

Table 1 — Molten carbonate fuel cells system description

Cell construction materials

Property	Anode	Cathode	Matrix
Material	Nickel with 2-10 wt% Cr, Al_2O_3	NiO with 2-5 wt% Li	υ-$LiAlO_2$ powder (fibre reinforced)
Powder property	2.5 microns	2.5microns	1 to 10 m^2/g
Thickness	0.5-1.0 mm	0.4-0.75 mm	0.5 to 0.75 mm
Porosity	60-70%	70-80%	70-75%
Avg Pore size	3 - 6 μm	7 - 10 μm	7 μm
Pore area	0.1-1.0 m^2/g	0.15-0.5 m^2/g	—
Method of fabrication	Tape casting, compaction & sintering	Tape casting, compaction & sintering	Hot pressing Tape casting & in cell sintering
Current Collector	Perforated Ni(1mm) or Ni plated steel	Perforated SS 316 steel (1.0 mm thick)	—
End Plates	Nickel Cladded SS & aluminized	SS 316L	

Electrolyte: K_2CO_3 (62 mol%) +Li_2CO_3 (38 mol%)
Composition: $LiAlO_2$(45 wt%) +K_2O_3(26.2 wt%) +Li_2CO_3 (28.8 wt%)
or
$LiAlO_2$(38-40 vol%) +[K_2CO_3 +Li_2CO_3] (60 vol%)
Standard operating conditions for the cell:
Operating Temperature: 650°C
Cell voltage: 1.047-1.090 (expected)
Current density: 150-160 mA/cm^2 at 0.80 Volt.
Fuel (Anode): H_2 +CO_2 (80 +20 Vol %) humidified at 55°C
Fuel utilization: >75 % (expected)
Oxidant (Cathode): 70% air +30% CO_2 or 33.3 % O_2 +66.7 % CO_2
Oxidant utilization: >50 % (expected)

1. To develop and establish reliable fabrication technology for the state of art materials for the electrodes, electrolyte matrix etc.

2. Design, fabrication of cell components and testing them at 650°C.

The details of the current R&D activities including the status of cell component technology and operational experiences of laboratory single cells, are described in the present article.

Experimental

(i) *Preparation of Matrix Material ($LiA10_2$)*

$LiA10_2$ (gamma variety) is the standard material of construction of the matrix to hold the molten electrolyte. The most common procedure adopted is the solid state reaction between Li_2CO_3 and γ- Al_2O_3 at 800°C for 10 hours leading to the formation of α-$LiA10_2$ which was subjected to a further high temperature treatment[11] at 1200°C for 24 hours to form γ- $LiA10_2$. A new proprietary technique for the synthesis of γ-$LiA10_2$ by combustion route from $LiNO_3$ and $A1(NO_3)_3$ aqueous solutions using urea as a fuel was also developed and reported[12]. Synthesis of $LaA10_3$ and $LaGaO_3$ was also carried out by solid state reaction method as alternate matrix materials. All the materials were identified by XRD to confirm their structure using JEOL Model JSM - 8030, X RAY Diffractometer.

(ii) *Preparation of Electrolyte Matrix Structures*

There are many techniques reported for the fabrication of electrolyte structures in literature[13,14]. Two different methods were employed for the fabrication of matrix tiles from the γ - $LiA10_2$ powder viz. by powder compaction followed by sintering and slurry casting method. A slurry formulation was prepared with polyvinyl butyral as binder in a solvent mixture of ethyl methyl ketone and ethanol. Apart from the above, the tape casting method was also employed for this purpose[15]. The details of the steps involved are presented in a schematic way in Fig.2.

Preparation of Porous Nickel Electrodes

Nickel powder (INCO 255) was used to prepare the electrodes. The anode was a porous nickel plate. Pure nickel and nickel-10 weight % chromium anodes were also fabricated. Several batches of electrodes were prepared by different techniques like loose power sintering(LPS), compaction techniques, slurry casting, tape casting(TC) etc. These electrodes were sintered in flowing hydrogen atmosphere at 700°C (except in the case of Cr containing electrodes where it was 900°C) for one hour.

The cathode was mainly composed of porous nickel oxide plate. The nickel electrodes were usually got lithiated and oxidised inside the cell. Prelithiated nickel oxide powders were prepared by solid

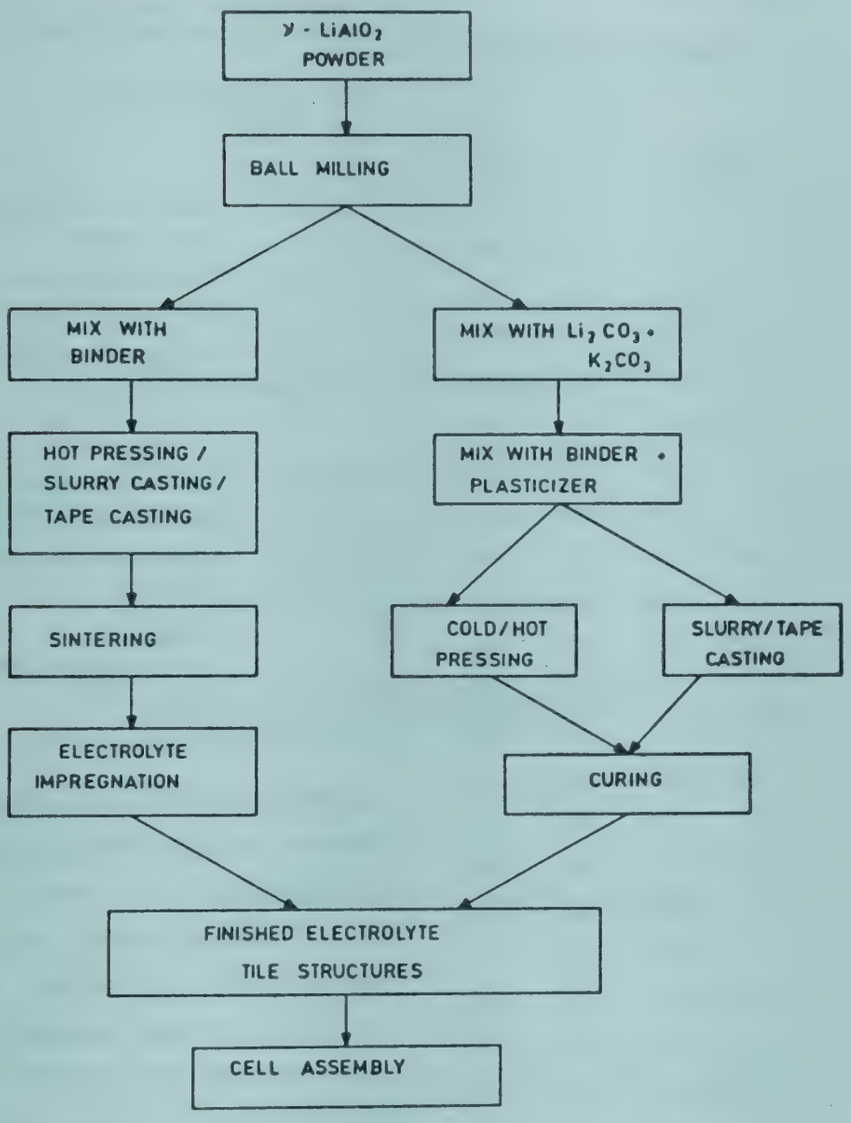

Fig 2 — Schematic of electrolyte matrix tile fabrication

state reaction of nickel and Li_2CO_3 and characterized by XRD. The volume porosity of the porous electrodes were determined by liquid absorption technique.

Cell Assembly

The cell assembly used for testing these electrodes was reported in our previous publication[16]. The end plates were fabricated from 316 stainless steel materials. Nickel screen current collectors were used. The details of the cell configuration are shown in Fig.3. The cell assembly was heated to the final temperature of 650°C in a programmed manner.

Results and Discussion

Electrodes

The details of the electrodes and the characteristics of the MCFC anodes and cathodes are presented in Tables 2 and 3 respectively. Electrodes of different area ranging from 10, 30 and 100 cm^2 were prepared by the different techniques like loose powder sintering (LPS) in graphite moulds at 700°C in hydrogen, cold compaction at 100 MPa and sintering (CCS), hot pressing (HP) at 50 to 70 MPa and 400°C, slurry casting, curing and sintering (SCS) and tape casting (TC).

Table 2 indicates that LPS technique can result in highly porous electrodes (>70%) and thickness can be maintained below 1.0 mm. Cr powder (-300 mesh size) was added up to 10 weight % and the sintering

Table 2 — Characteristics of MCFC Anodes

Sl.No.	Composition	Method	Area cm^2	Thickness mm	Porosity %
1.	Ni	LPS*	10	1.0	70
	"	"	30	0.8	65
	"	"	30	1.0	68
	"	"	30	1.3	70
	"	"	30	1.5	65
	"	"	100	0.8	65
2.	Ni	CCS	10	1.0	50
	"	"	30	0.8	55
	"	"	100	0.8	60
3.	Ni	HP	30	1.0	50
	"	"	100	1.0	50
4.	Ni+CMC(10%)	SCS	10	1.0	60
	"	"	10	1.2	60
	"	"	30	1.0	60
5.	"	TC	30	0.8	55
	"	"	100	0.8	60
6.	Ni+8% Cr	LPS	10	1.0	60
	"	"	30	0.8	62
	"	"	100	0.8	65
7.	"	CCS+	10	1.2	55
	"	"	30	1.0	55
8.	Ni+10% Cr	LPS+	30	1.0	65
	"	"	10	1.2	60
	"	"	100	1.0	60
	"	"	100	0.8	65
9.	"	CCS+	10	1.2	55
	"	"	30	1.0	55
	"	"	100	1.0	58
10.	Ni+10% Cr	SC+/TC	100	0.8	70
11.	Ni bilayer	CCS	30	1.0	50
12.	Ni/Ni+Cr 10% bilayer	CCS+	30	1.2.	50

Abbreviations

LPS : Loose powder sintering in graphite moulds at 700°C in H_2 for 1 h

CCS : Cold compaction 100 mPa and sintering at 700°C in H_2 for 1 h.

HP : Hot compaction at 400°C and 50-70 nPa

SCS : Slurry casting, curing and sintering the green product at 700°C in H_2 for 1 h.

TC : Tape casting by Doctor blad arrangement and sintering at 700°C in H_2 for 1 h.

+For Chromium added electrodes sintering was done at 900°C in H_2 for 1 h

Table 3 — Characteristics of MCFC Cathodes

Sl.No.	Composition	Technique	Area cm^2	Thickness mm	Porosity %
1.	Ni	Compaction+Sintering+Lithiation	30	1.2	60
2.	Ni	Prelithiation+Compaction+Sintering	30	1.0	70
3.	Ni+NiO	Prelithiation+compaction+sintering	10	1.5	60
4.	"	"	30	1.2	5.7
5.	"	Compaction+sintering+Lithiation (in cell)	30	1.0	60
6.	"	Slurry casting+in cell lithiation	30	0.8	65
7.	"	Compaction+Lithiation+sintering	30	1.0	60

was done at 900°C. No shape or size change was observed during sintering operation. It is found that LPS technique is a convenient technique to follow. The SCS technique was carried out after preparing a slurry with carboxy methyl cellulose as the binder. The porosity values obtained for the compacted and sintered electrodes (CCS & HP) were lower than those obtained by other methods. Still they have comparatively low porosity values than the specified values indicated in Table 1. The TC technique is being pursued further to prepare thin (<1 mm) electrodes of size >100 $cm^2$100 cm^2 with the desired porosity values.

From Table 3 it is evident that when nickel electrodes were lithiated, a reduction in porosity values was observed. The electrodes prepared by LPS technique did not reveal any cracks during lithiation and oxidation under in cell conditions. The sintered compacts showed porosity values <60%, but were also found to be stable. In lithiated NiO powder samples prepared by solid state reaction of Ni with Li_2CO_3, the lithium content was varied from 2 to 20 weight % and analysed by XRD technique[17]. The *ex situ* lithiated NiO was mixed with Ni (50:50 wt %) and formed into electrodes by the above methods.

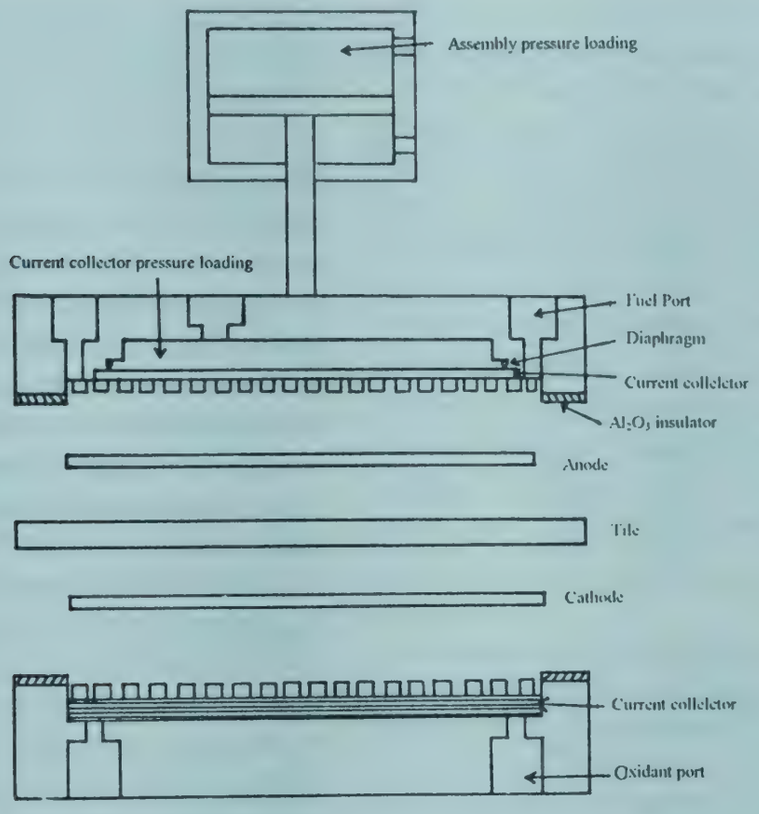

Fig 3 — Schematic of the MCFC test assembly

Table 4 — Characteristics of MCFC electrolyte matrix materials

Sl.No.	Component	Method	Condi-tions (°C)	size (cm^2)	thick ness (mm)	porosity (%)
1.	$LiAlO_2$	Hot pressing with binder	600	10	2.00	30
2.		Cold compaction	1200	10	2.00	40
3.		Slip casting	1200	30	1.00	50
4.		Tape casting (nonaqueous process)	1200	30	0.70	50
5.		Tape casting (aqueous process)	1200	100	0.75	60
6.	$LiAlO_2$ + Carbonate	Hot pressing mixture*	350	30	1.0	30
7.		Slip casting	**	30	0.8	20
8.		Slip casting	**	100	0.7	
9.		Tape casting (non-aqueous process)	**	100	0.6	

* $LiAlO_2$(45 wt%) +K_2CO_3(26.2 wt%) +Li_2CO_3(28.8 wt%)

** In cell sintering at 650°C

Table 5 — Performance characteristics of MCFC single cells at 650°C

Cell No.	Electrode area (cm^2)	OCV(V)	Current drain(A)	CV(V)	Time of testing(h)
2	3	0.820	0.030	0.60	6
7	3	0.863	0.040	0.62	5
17	10	0.850	0.300	0.60	15
21	10	0.855	0.850	0.65	10
23	20	0.880	1.700	0.68	12
24	100	0.900	4.000	0.62	20
27	100	0.900	2.500	0.65	30
46	30	0.850	1.000	0.68	50

Table 6 — Design targets

Characteristics	Stage 1	Stage 2
Size(Watts)	10	500
Electrode area (cm^2)	150	1000
Single cell voltage (V)	0.7	0.7
Current density ($mA.cm^{-2}$)	80 - 100	120 - 150
Life expectancy (h)	100	1000
Number of cells in the stack	1	5/10

Electrolyte Matrix

The lithium aluminate powder prepared by the two methods discussed earlier were found to be the gamma variety by XRD technique[18]. The average particle size of the γ- $LiAlO_2$ powder prepared by the solid state reaction was 16 μm. The combustion technique yielded very fine powder of gamma $LiAlO_2$ with particle size in the range 2- 5μm and BET surface area 10 m^2/g[12]. The latter method was found to be the most convenient method and was therefore employed in further investigations.

The most critical part of a McFC is the preparation of the electrolyte matrix. The matrix holds the eutectic mixture of 62 mol% K_2CO_3 and 38 mol% of Li_2CO_3 as the electrolyte in the molten state at 650°C. It is therefore expected that fabrication of highly stable and thin structures of matrices (tiles) either alone or in combined form with the electrolyte is detrimental to the operation of the cells. Hot pressing, slurry casting and tape casting techniques were followed to produce uniform and thin structures[18].

The characteristics of the electrolyte matrix prepared by the various techniques are given in Table 4. Hot pressing resulted in thick and stable matrix structures. The incorporation of the electrolyte into the matrix was a difficult task due to low porosity values. The slurry casting of γ- $LiAlO_2$ powder with suitable compositions of binder and plasticizers were tried to produce tiles of thickness less than 1 mm. The same has been modified by tape casting technique to produce thin structures[19] (patent submitted in India)

In another method the $LiAlO_2$ (45 wt %) was mixed with K_2CO_3 (26.2 wt %) + Li_2CO_3 (28.8 wt %) in a ball mill. The combined powder was also used to prepare the matrix as per Fig.2. The casting of combined matrix and electrolyte powders in the form of a tape was found to be the most convenient route for preparing thin tiles. These tapes were used directly between the electrodes in the cell assembly without prior sintering. The slow rise of cell temperature to 650°C resulted in the removal of the binder materials and the powder got sandwiched between the electrodes. This process is referred as "in cell sintering"[19]. The integrity of these tapes were fine with respect to their application in the MCFC environment.

Fuel Cell Assembly

The electrodes and the matrix materials were assembled to form the single cells and tested at 650°C. The operating conditions of the cell are given below:

Pressure: 1.0 atm

Gas composition:

Anode gas: H_2 80 Vol % + CO_2 20 Vol % (80-100 ml/min)

Cathode gas: O_2 33 Vol % + CO_2 67 Vol % (50-100 ml/min)

Nearly 40 cells were tested for different durations ranging from 10 - 50 hours. The characteristics of these cells are presented in Table 5. The low open circuit voltage of the cells were ascribed to the difficulties encountered in the supply of feed gases at uniform flow rates and to the corrosion of materials. The wet seal area was not protected from the carbonate coming out from the matrix at 650°C. This problem is being looked into by developing suitable insulator coating methods.

Development of Alternate Matrix Materials

$LaAlO_3$ powder has been prepared by solid state reaction method and characterized by XRD method. The chemical stability of this powder in molten carbonate mixture at 650°C has been studied for a period of 120 - 500 hours by weight loss method. The work is in progress.

The current programme of development on MCFC at CECRI has been sponsored by MNES, New Delhi. The goal of this programme is to establish the fundamental technology of fabricating a cell stack having 1000 cm^2 area electrodes with a capacity of 500 watts. The MCFC development work which is at present in the 1 watt/cell level is to be scaled up to 10 watts/cell and then to 100 watts/cell (Table 6). This can be accomplished by proper optimization of the matrix and electrode structures to achieve current density values of the order of 150 mA/cm^{-2} from the current level of 40 mA/cm^{-2}. Simultaneously the cell size will also be increased to get higher current output.

The first stage is envisaged at the development of MCFC with 150 cm^2 area electrodes with a capacity of 10 watts per cell. The following are the focus points of the current programme:

(i) Optimization of the parameters governing the tape casting process for producing electrolyte matrix tiles and electrodes. The increase in the area of components require not only increased slurry consumption but also longer tape casting time, thereby increasing the difficulty in obtaining tapes of uniform thickness. Efforts are currently made on the development of tape casting process for large area components.

(ii) Designs for the end plates, fabrication of and plates, fabrication of bipolar plates and external manifolding type cell assembly for multicell stack for testing 150 cm^2 size electrodes.

(iii) Creation of a test facility to test large number of cells.

The second stage involves the scaling up of the cell area to 1000 cm^2 with an expected output of 100 watts per cell with a final aim to demonstrate 500 watts capacity multicell stack. The following tasks will be completed during this stage:

(a) Design and fabrication of cell hardwares for testing 1000 cm^2 area electrodes

(b) Design and testing of multicells stack up to 500 watts capacity

(c) Performance verification with simulated gas compositions.

It is envisaged that during this course, problems relating to fabrication of bipolar plate, stacking, gas distribution and sealing will be addressed. The expertise gained will be used to scale up the stack size in the range 1 to 5 kW and build up experience in stack engineering, system design and system management. The ultimate goal is the design and fabrication of 10 kW MCFC with internal reforming action suitable for natural gas. This will enable CECRI to go in stream with the international programme.

Conclusions

A steady progress has been made in the demonstration of molten carbonate fuel cells at CECRI during the past four years. Based on the development strategy described above, efforts are being made on the enlargement of components, their long term operation, the development of alternate materials, and so on, towards demonstration of 100 watts cell with the electrode area of 1000 cm^2.

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Effect of Electrolytes on Zeta Potential of Beneficiated Indian Bentonites

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Zeta-potential of beneficiated Na– and Ca- bentonites obtained from Bhavnagar locality, Gujarat, India and treated with varying amounts of $Ca(OH)_2$ are measured by a NORTHROP-KUNITZ horizontal cell and non-polarising Zn-$ZnSO_4$ electrodes. Dependence of zeta potential on particle size, clay concentration and electrolyte concentrations respectively are also studied.

The results indicate a four-stage change in zeta- potential and viscosity when $Ca(OH)_2$ is added in increasing amounts to Na– bentonite suspensions. In the first stage, the addition of up to 2 per cent (w/v) of lime caused no change in zeta-potential indicating a counteracting effect of Ca^{++} adsorption and reaction of OH^- ions to increase the negative surface charge and a slight change in viscosity. In the second stage, the addition of more lime (upto 3 per cent) re[illegible] a rapid decrease in zeta- potential and sudden increase in viscosity. In the third stage, additional lime (from 3 to 6 per cent) led to a slow decrease in zeta-potential but a continued rapid increase in viscosity and the formation of distinct large flocs. In the fourth stage, the additional $Ca(OH)_2$ (from 6 to 12 per cent) caused only a very slight change in Zeta- potential and slight decrease in viscosity. In the Ca-bentonite- $Ca(OH)_2$ system, the first stage was an increase in zeta-potential due to dominant influence of OH^- potential-determining ions. The second stage was a rapid decrease in zeta-potential and an increase in viscosity and this situation corresponding to the third stage of treatment in the Na^+- clay. The end of the second stage is the lime retention point, after which excess lime is used for pozzolanic reaction. Soils have been stabilized with lime since ancient times, and lime is now being used in road building throughout the world. Additions of hydrated lime, $Ca(OH)_2$, to plastic clays rapidly reduces their plasticity and facilitates handling. The montmorillonite clays which are most common are improved by treatment, even though in the natural state they are usually[1] already calcium saturated.

Introduction

The electrochemical properties of colloidal solutions (Bentonite- water system) of inorganic substances show a characteristic behaviour. In the earlier stages of the development of this subject more attention was paid to their behaviour in an electric field, their precipitation by electrolytes and their stability, but little emphasis was laid on the potential and capacity of the double layer, the interfacial energies and adsorption in accounting for these properties. The scientific study of these bentonite clay systems have aroused lot of interest among the scientific community in view of wider application of bentonite in as diverse industries as petroleum, petrochemical, agricultural and constructional engineering work[2].

The existence of bentonite as basically a negatively charge particle has been demonstrated with streaming current or zeta potential measurements. The measurements show that bentonite has a negative zeta potential of 55 to 96 mV and also depend upon the nature of bentonites. The extent of the charge is dependent on the concentration and the

* For correspondence

effectiveness of the suspension hydration[3]. The swelling mechanism is in accordance with the electrokinetic theory mainly zeta-potential, sodium bentonite exhibiting greater swelling than calcium bentonite[4].

The present study was initiated to learn the effect of calcium hydroxide on zeta-potential of beneficiated Na– and Ca- bentonites.

Mathematical Concepts of Zeta Potential

Smoluchowski[5] showed that the electrophoretic mobility μ of a particle moving through a liquid of viscosity η and dielectric constant D, under the influence of a homogeneous electric field, is given by

$$\mu = \frac{g D E}{4 \pi \eta}, \quad ...(1)$$

where, g =Zeta potential, and

E =Potential gradient of electromotive force.

This equation is for large insulating particles, or for large cylinders moving with their axes perpendicular to the electrode; provided the radius of curvature at all points of the surface is much greater than the thickness of the double layer.

Booth[6] and Henry[7] considered the corrections necessary when the surface conductivity is taken into account. Henry shows that for an insulating particle,

$$\mu = \frac{g DE}{4 \pi \eta} \times \frac{\lambda_o}{\lambda_o + (\lambda_s / a)}, \quad ...(2)$$

where, λ_o =specific conductivity of the medium, λ_s =surface conductivity of the particles, a =radius of particle.

Street[8] showed that surface conductivities of kaolinitic particles in KBr solutions of 0.05 N to 0.0083 N concentrations had the values of 1.33×10^{-9}/ohm^{-1} and 3.55×10^{-9}/ohm^{-1} respectively or very low.

The effect of relaxation, arising from deformation of the oppositely charged diffused double layer, has a retarding force on the particles. In an applied electric field the charge of the diffuse double layer is displaced in a direction opposite to the movement of the particles. This not only retards the electrophoresis by its movement, but also by the resulting dissymmetry of the double layer, it sets up a retarding potential difference. A correction has been suggested by Booth[9].

The studies involve the use of Smoluchowski's equation with two assumptions, viz., the magnitude of the relaxation effect as well as surface conductivity of bentonite particles can be ignored.

This is due to that:

(a) The electric field does not deform the double layer or the magnitude of the relaxation effect and so can be neglected[9].

(b) The surface conductivity values of bentonites have been reported very low.[8]

Methods and Materials

Preparation of Samples

All the samples used were beneficiated Na–bentonite and Ca- bentonite. Bentonites clay from Bhavnagar locality, Gujarat (India) are being used for studying the effect of $Ca(OH)_2$ on zeta-potential. Both contained about 80-90 per cent <5μ montmorillonite. The cation exchange capacities determined by the ammonium acetate method at *p*H 7.0 were 88 and 83 me/100 g for the Na–Bentonite and Ca-Bentonite, respectively.

About 2 per cent Na– bentonite suspension was agitated for at least 8 h with an electric stirrer. Particles of different sizes ranging from 0.5 to 12 μ were pipetted after settling. Then 1 ml of each size fraction was resuspended in 100 ml of 0.0029 N NaCl solution, which was used for conducting current during electrophoretic measurement.

Na–Bentonite : Various amounts of reagent grade $Ca(OH)_2$ were added to 100 ml of 2 per cent well-dispersed Na–bentonite suspension in 125 ml Erlenmeyer flasks, and thoroughly mixed. Then the flask was tightly stoppered with rubber stoppers, and the mixture was allowed to cure at 24°C for 7 days. At the end of the curing period, 1 ml of each suspension was withdrawn and mixed with 100 ml volume of distilled water in a volumetric flask. The reason for using distilled water instead of 0.0029 N NaCl was to avoid any complications due to cation exchange. Preliminary results showed that cation exchange effected the zeta-potentials. The large flocs which formed as a result of the addition of lime were dispersed in 1 to 2 min with a 1 kW ultrasonic generator to give particles in the desired size range, i.e. from 0.5 to 12 μ. The electrophoretic movement of particles was observed at 23°C room temperature after atleast 4 h equilibration.

Ca-Bentonite: Procedures for sample preparation were the same as those used for Na– bentonite – $Ca(OH)_2$ systems except that 0.05 g/100 ml H_2O

suspension was used for zeta-potential measurement.

Viscosity Measurements

Relative viscosities of freshly prepared Na–bentonite- $Ca(OH)_2$, mixtures and Ca-bentonite-$Ca(OH)_2$ mixtures were measured with a Stormer paddle-type viscosimeter after 1 h equilibration with shaking at 25°C. The paddle was actuated by a 25 g weight. The results are expressed in minutes required for 100 revolutions of the rotor[10].

Zeta-potential measurements A horizontal Northop-Kunitz Cataphoresis apparatus (Arthur A Thomas Co., USA) was used to determine the zeta-potential. The complete apparatus consists of the cataphoresis cell, and a right-hand and a left-hand electrode vessel with non-polarizable C.p. zinc electrodes. One-tenth normal zinc sulphate solution was used to fill the vessel for salt bridges.

The movements of the clay particles were observed by an ordinary Bauch & Lomb microscope equipped with dark field condenser and external illumination to eliminate the heating effect from a substage lamp. The total magnification used was of the order of 420X, a combination of a 20X micrometer eyepiece and a 21X objective lens. For each measurement the passage of at least 7 particles in each direction across 92.4 μ on the ocular scale was timed by means of a stop watch.

To measure the true electromobilities independent of any electro- osmotic effect, it is necessary that the correct stationary layers in the cell be observed. A relatively simple calculation shows that these layers are located at 21.1 per cent. Of the total height from each inner wall for an infinitely wide cell[11] a very wide cell was therefore used, and measurements were made at these stationary levels. The conductivity of the sample solution was measured separately with a conductivity bridge. Current through the cell was measured with a micro-ammeter with a 0-160 μA scale and 1 per cent accuracy. The d.c. potential was supplied by dry cells, and a switch was included in the circuit to reverse the polarity without effecting the reading on the ammeter. Thus the potential gradient E in equation (1) can be calculated as follows:

$$E = \frac{i}{A \cdot L}, \qquad ...(3)$$

where, i =current (amps), A =cross-section area of the cell (0.0679 cm^2), L =specific conductance of the suspension ($ohm^{-1}cm^{-1}$).

Viscosity (η) of the suspension was measured by conventional methods and dielectric constant (D) was seen from literature as shown in Table 1[12]. Substituting the values of potential gradient (E), electrophoretic mobility (μ) Viscosity (η) and dielectric constant (D), we can easily calculate the absolute value of zeta-potential (mv) of the desired bentonite suspensions.

Preliminary Experimental Studies

Relation Between Particle Size and Zeta-potential

The zeta-potential is constant in the particular range of the particle size studied as shown in Fig 1. The absolute value of zeta-potential tend to decrease slightly with an increase in particle size[13].

Table 1 — Physical Constant (Dielectric Constant) of Water[12] as a Function of Temperature

Temperature °	Dielectric constant	Temperature °C	Dielectric constant
15	82.22	25	78.54
16	81.82	26	78.17
17	81.17	27	77.83
18	81.10	28	77.16
19	80.74	29	77.12
20	80.36	30	76.75
21	80.00	31	76.38
22	79.63	32	76.04
23	79.27	33	75.68
24	78.69	34	75.33
		35	75.00

When we take the dielectric constant of air as one, the dielectric constant for water between 0 and 100°C can be calculated by using the equation :

$D = 78.54\ (1-4.579 \times 10^{-5})(t-25) + 1.19\ (10^{-5})\ (t-25)^2 - 2.8\ (10^{-8})\ (t-25)^3$

Average deviation is ± 0.03 per cent

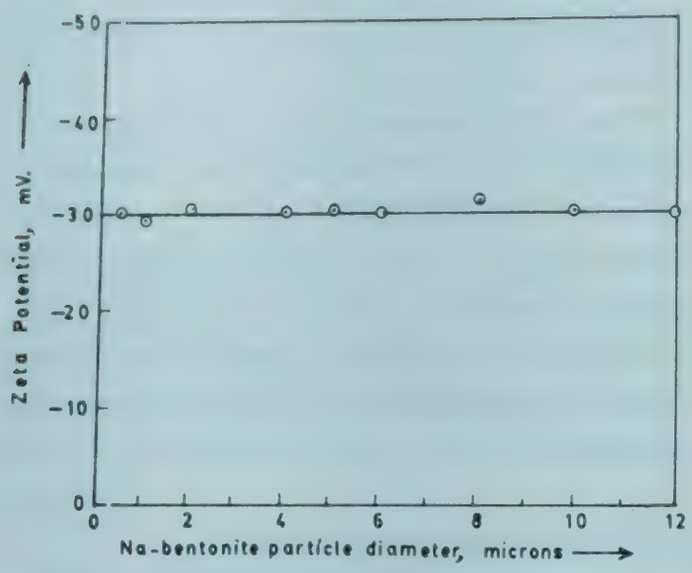

Fig 1 — Effect of particle size as calculated from settlement analysis on zeta potential

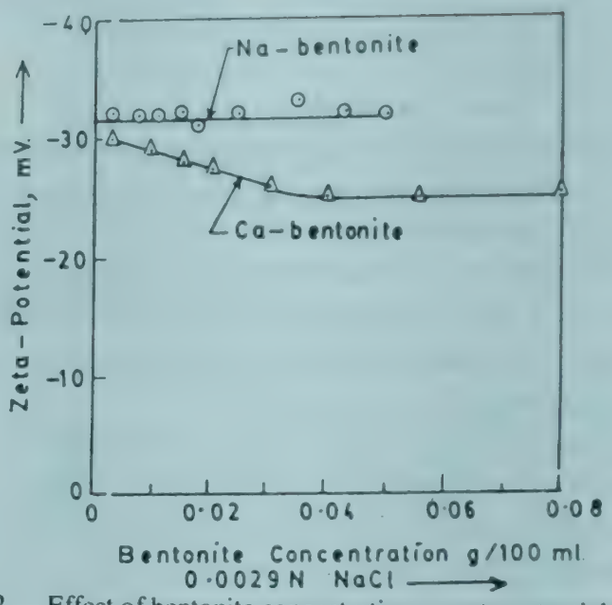

Fig 2 — Effect of bentonite concentration on zeta-potential in dilute NaCl solution.

Effect of Clay Concentration on Zeta-potential

Studies on the zeta-potentials of well-dispersed Na–bentonite and Ca-bentonite in suspensions ranging from 0.003 to 0.05 g/100 ml in 0.0029 *N* NaCl solutions indicated that the zeta- potential of Na–bentonite was not effected significantly by its concentration (Fig 2).

In the Ca-bentonite suspensions, absolute values of zeta- potential decreased with clay concentration, particularly in the range of 0.003 to 0.03 g/100 ml (Fig 2). As the Ca-bentonite concentrations were very low compared with the total amount of Na^+ ions present in the medium some ion exchange reaction may have caused this change.[13]

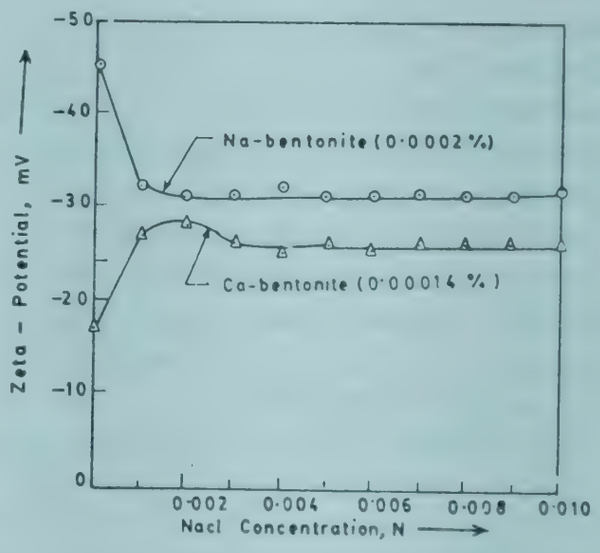

Fig 3 — Effect of NaCl concentration on zeta-potential of bentonites

Results and Discussion

Effects of NaCl and $CaCl_2$

The zeta-potential of Na–bentonite (CEC =0.018 m.e./100 ml suspension) decreased sharply from 45 to 32 mv as the NaCl concentration was raised from 0 to 0.1 m.e./100 ml. The decrease was probably due to compression of the diffuse double layer of Na^+ ions upon addition of NaCl. The zeta-potential of Ca-bentonite (CEC =0.0126 m.e./100 ml suspension) increased sharply from 17 to 27 mv in the same range of NaCl concentrations, and then levelled off, as shown in Fig 3, probably as a result of ion exchange and expansion of the double layer.

The zeta-potential of Na– bentonite decreased drastically from 45 to 20 mv upon addition of $CaCl_2$ equivalent to its CEC as shown in Fig 4. The zeta-potential then continued to decrease gradually as more $CaCl_2$ was added, with no break in the curve. This suggests that an initial rapid cation exchange took place owing to the preferential adsorption of available Ca^{++} ions, but complete cation exchange occurred only when $CaCl_2$ in excess amounts was added.[13]

Addition of $CaCl_2$ to Ca-bentonite change its zeta-potential only slightly even when the addition of $CaCl_2$ was more than twice its CEC (Fig 4). The

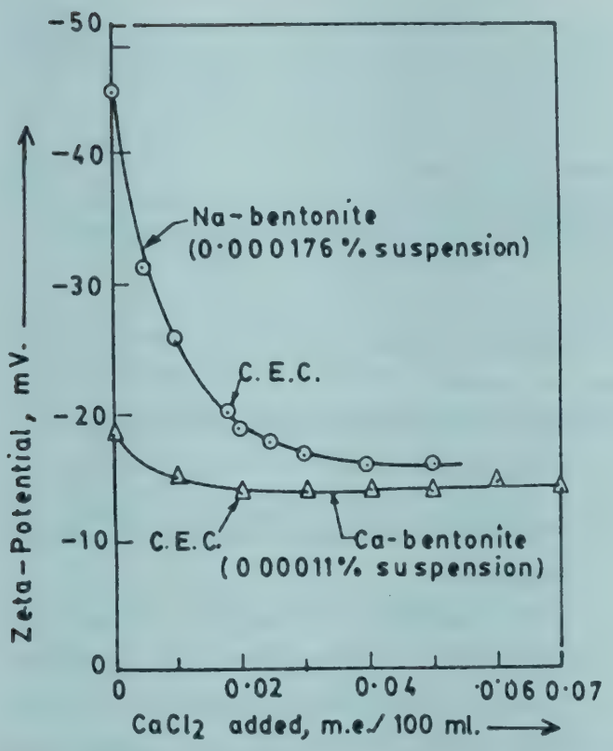

Fig 4 — Effect of $CaCl_2$ concentration on zeta-potential of bentonites

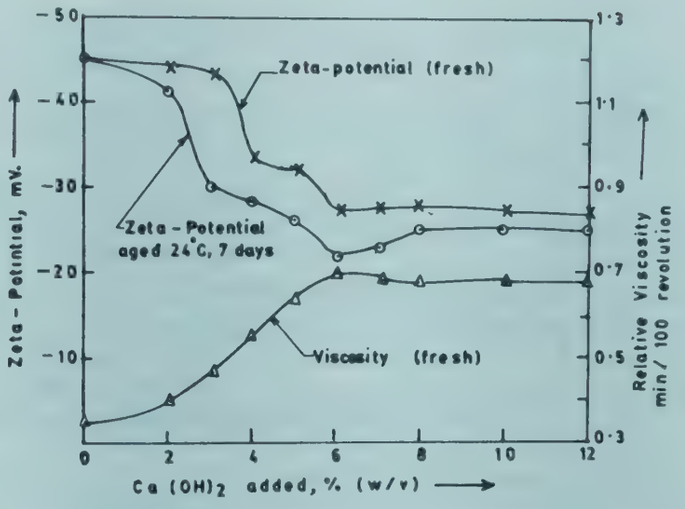

Fig 5 — Effect of $Ca(OH)_2$ content on zeta-potential and viscosity of Na^- bentonite before and after curing

slight decrease in zeta-potential with $CaCl_2$ was probably caused by further compression of the diffuse double layer of Ca^{++} ions.[13]

Effects of $Ca(OH)_2$ On Zeta-Potential and Viscosity

The addition of $Ca(OH)_2$ to Na–bentonite suspensions resulted in a four-stage change in zeta-potential, and the viscosity changes follow an inverse trend as shown in Fig 5. In the first stage, addition of $Ca(OH)_2$ up to 2 per cent (w/v) causes essentially no change in zeta-potential. This phenomenon is contrary to that observed in the Na– bentonite -- $CaCl_2$ system at *p*H around 7, indicating that the potential determining OH^- ions at high *p*H are playing a major role in increasing the negative surface charge of the clay crystals, counteracting the effect of Ca^{++}adsorption and exchange. The viscosity is low at this stage, suggesting that Ca^{++}adsorption may be mainly on the internal exchange sites and also the energy of attraction between clay micelles remains very low.[13]

In the second stage, additional $Ca(OH)_2$ up to 3 per cent / (w/v) in the aged sample, and up to 4 per cent (w/v) in the freshly prepared samples caused a rapid decrease in zeta-potential accompanied by a considerable increase in viscosity and the appearance of flocs. Although the Na– bentonite was still only partially saturated in the interlayer with Ca^{++}ions and the total Ca^{++} adsorption was high enough to play a dominant role in decreasing the zeta-potential. Furthermore, some of the available Ca^{++} ions must have been used for linking the clay micelles, since viscosity increased rapidly in this stage.[13]

In the third stage, addition of $Ca(OH)_2$ from 3 per cent (w/v) to 6 per cent (w/v) resulted in a slow decrease in zeta- potential, but with a continued fast increase in viscosity, which reached the maximum at about 6 per cent (w/v) of $Ca(OH)_2$. Formations of distinct large flocs were observed at the same level of $Ca(OH)_2$ treatment. This, plus the relatively small change in zeta- potential, suggests that Ca^{++}ions and OH^- ions were counteracting in their effect on micellar charge, the Ca^{++}ions being adsorbed in such a way as to act as bridges linking the clay particles. The dissociation of weakly acidic sites by OH^- ions probably reached full capacity at the end of this stage, 6 per cent (w/v) of $Ca(OH)_2$, indicated by the maximum increase in viscosity and formation of distinct large flocs.[12]

In the fourth stage, which starts on the addition of 6 to 12 per cent (w/v) $Ca(OH)_2$, caused only a very slight change in zeta- potential due to slow utilization in pozzolanic reactions after the dissociation of the weakly acidic terminal groups reaches full capacity. The relative viscosity decreased slightly, and was accompanied by the continued formation of distinct large flocs.

That the zeta-potential of the freshly prepared samples was higher than that of the aged samples at comparable level of lime content may be due to

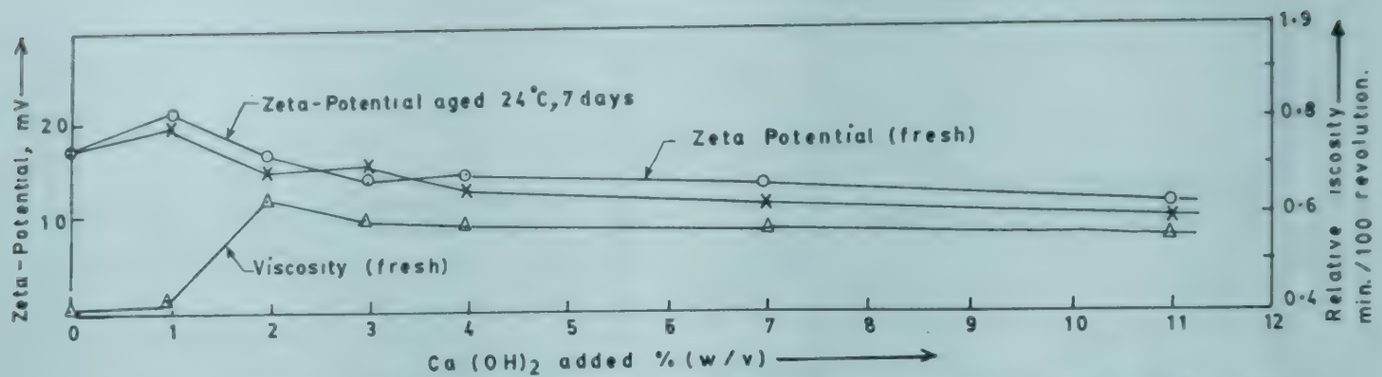

Fig 6 — Effect of $Ca(OH)_2$ content on zeta-potential and viscosity of Ca-bentonite before and after curing

incomplete cation exchange in the freshly prepared samples.[13]

Ca-bentonite

The zeta-potential of Ca-bentonite increased rapidly from 17 to 21 mv upon addition of 1per cent (w/v) $Ca(OH)_2$ of clay (Fig 6), verifying the increase in negative surface charge at high *p*H. Change in viscosity at this stage was negligible.[13]

Addition of upto 2 per cent (w/v) $Ca(OH)_2$ of clay caused a rapid decrease in zeta-potential from 21 to 15 mv, associated with a sudden increase in viscosity upto a maximum value. Therefore, Ca^{++} ion adsorption must play a dominant role, balancing the now more highly negative clay charges and linking the clay particles. The stage was accompanied by the formation of distinct large flocs. Moreover, the plastic limit also reached the maximum at the same level of $Ca(OH)_2$ treatment, indicating the maximum occlusion of free water within the flocs.[13]

The zeta-potential of the freshly prepared samples in this last stage was lower than that of the aged samples, probably indicating removal of free $Ca(OH)_2$ through pozzolanic reaction in the aged samples.

Conclusions

The main conclusions of studies of electrokinetic properties (zeta-potential) of lime-treated Gujarat bentonites are given below:

(i) The zeta-potential of lime-treated Na– and Ca- bentonites is inversely proportional to the viscosity.

(ii) Small amounts of $Ca(OH)_2$ added to bentonite increase negative charges on the clay particles, probably by dissociation of clay OH^- groups. The action is complicated in Na–bentonite by accompanying partial ion exchange.

(iii) Further additions of $Ca(OH)_2$ allow Ca^{++} adsorption to compensate the increased negative charge gradually and cause floc formation. Both a high *p*H and presence of polyvalent cations are required for this type of flocculation.

(iv) Complete Ca^{++} saturation is not necessary for this flocculation, flocculation and partial exchange occur rapidly, but complete interlayer cation exchange is comparatively slow and probably continues by diffusion.

(v) Dissociation of clay OH^- groups, and accompanying adsorption of Ca^{++} ions to change viscosity, reaches a maximum at about 6 per cent (w/v) $Ca(OH)_2$ for Na– bentonite, and about 2 per cent (w/v) $Ca(OH)_2$ for Ca-bentonite. Lime added in excess of these amounts remains undissolved until needed to replenish the system as the dissolved lime is used up in slow pozzolanic reactions.

(vi) In the case of Na– bentonite samples, the zeta- potential of the freshly prepared samples was higher than that of aged samples at comparable level of lime content may be due to incomplete cation exchange in the freshly prepared samples.

(vii) In the case of Ca-bentonite, the zeta-potential of the freshly prepared samples in this last stage was lower than that of the aged samples, probably indicating removal of free $Ca(OH)_2$ through pozzolanic reaction in the aged samples.

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Low Cost Mini Coal Beneficiation: Screening of Sand and Fines from Open Cast Mine Coal — A Case Study

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Coal supplied to Thermal Power Stations comprises of extraneous material like stones, shales, sand, fines, overburden, etc. which get mixed in the process of mining. It is generally known that to eliminate them completely is not possible. Although many Thermal Power Stations have been successful in screening out large size stones and shales from raw coal in the past, there still remains one of the major constituents of coal, i.e., sand or fines and overburden carried over from mines to power stations. The presence of sand in the coal is found highly detrimental, specifically to the 210 mW boilers with high flue gas velocities and also to the coal mills. An attempt was made at one of the thermal power stations for screening out sand from raw coal received particularly from Mazri and Ballarpur open cast mines with high content of sand and it proved successful. A report of Case Study incorporated here gives details of screening of sand and fines from coal. The benefits achieved are many and the modifications are made with less resources.

Screening Arrangement

A technique devised by the author makes use of the vibrations of electrical vibrating screen, fitted above the secondary crusher for separation of sand and fines from the raw coal received from coal mines at the power stations.

With the picking up of stones and shales from running coal conveyors, the performance of coal mill improved. However, with the removal of the sand and sticky fines from raw coal, received at Power Station, further improvement in overall performance of coal milling plant and Boiler Loading can be certainly achieved.

This technique is similar, in effect, to that of coal beneficiation plant and that too with meagre investment.

The present coal beneficiation plant cost is @ Rs 70 crore for 4 mM tonne/y which will be sufficient for 3 x 210 mW units. However, it will take more than 5y due to long gestation period, financial resource crunch and the reluctance of coal supply companies to set up plants at coal mines for supply of beneficiated coal to Power Stations.

Until the real benefits of beneficiated coal are fully realised, the untreated coal will keep on playing havoc in power stations due to its high contents of abrasive ash, sand, and fines.

The screening of sand and fines can be carried out during October to May every year and screened crushed coal stacked during dry season can be used from June to September, i.e., in rainy season to avoid choking problems due to wet coal and consequent loss of generation.

The screened coal can be stacked in pyramid shape however, the stacking ground should have effective peripheral drains.

Advantages Accrued by Screening 5-10% Sand/Fines are as follows:

(i) Improving load on 210 mW Units sets to 150/160 mW, i.e., above technical minimum without necessitating continuous oil support as against earlier load equal to 120/140 mW by handling coal without separation of sand from coal.

(ii) Results in substantial saving in precious fuel oil.

(iii) Reject percentage from coal mills get reduced drastically leading to saving in reject handling.

(iv) Boiler tube failure rate gets definitely reduced as the sand responsible for causing abrasive effect on high pressure boiler tubes gets separated before bunkering of coal going to coal mills.

(v) Results in less damage to wear components of coal mills and subsequent enhanced period of mean time between failures and performance improvement of coal mills.

(vi) The technique of separation of sand and fines in coal which can be carried out in a dry season is useful throughout the year except during rainy season. However, stacked screened coal in dry season can be used during rainy season to avoid most serious choking problems in Thermal Power Stations due to wet and sticky coal.

Report on Case Study — Suggestion and Implementation for Achieving Benefits

(1) In February, 1993 M/s. WCL despatched 14 Nos. coal rakes (about 43044 m tonne) from Mazri coal mines to Bhusawal TPS. The Mazri coal contains excessive sand and use of this coal in Power Station leads to reduction in load on 210 mW TA set to less than technical minimum (120 to 140 mW) necessitating a continuous and costly oil support.

During February 1993, the oil consumption due to poor coal quality was 655 KL for station. Reject percentage from coal mill increased from 2 to 4.68% in U-3 (3368 mtonne) and to 2% in U-2 (1443 mtonne).

Due to abrasive effect of sand there were three Boiler Tube Failures in Units 2 and 3 in February 1993.

All attempts to stop the despatch of Mazri Coal to BTPS proved futile.

Some other efforts were made to improve load on the Units, viz. checking of coal fines, PA flow, underbowl pressure, excess air, vacuum, etc. However, it was not possible to improve load beyond technical minimum (120-140 mW).

It was suggested by author to make an arrangement by providing 10 x 10 mm size screen mesh below 50 x 50 mm size screen of vibratory screen above the secondary crusher and the fines passing out from 10 x 10 mm screen to be by-passed outside the crusher house, i.e., not allowed to pass neither to crusher stream nor to by-pass stream of crusher into conveyor 16A.

For making above scheme practicable, various combinations were tried departmentally and it took about two months for fabrication of 300 x 300 mm chute, drilling of holes through concrete floors of crusher house, fabrication of 10 mm x 10 mm screen and providing manually operated gate, etc., and putting modified system into service.

An arrangement was made to by-pass fines outside crusher house during handling of sandy coal. However, in case of handling coal without much fines or sand the gate can be closed to prevent coal from going outside crusher house and can be allowed to pass through by-pass stream of crusher.

With the above arrangement of by-passing of fines along with sand, it is possible to improve load to or above technical minimum without requiring continuous oil support for flame stabilization and with comparatively less reject percentage from coal mills since major portion of sand is screened before the coal mills.

Further the coal mill wear parts are saved from accelerated damage due to abrasive effect of sand and also 'Boiler Tube Failures' could be reduced.

(2) Testing of Sand Percentages

Samples of screened fines were tested by measuring sand percentage in Chemical Laboratory and results are given in Table 1.

Table 1 — Ash percentage of bunkered coal =38%

Samples of screened fines	Ash % of screened reject	Difference in ash % of screened reject and bunkered coal	Remarks
Sample - 1	47	9	
Sample - 2	48	10	
Sample - 3	47	9	Indicates the presence of extraneous material like sand
Sample - 4	47	9	
Sample - 5	48	10	

(3) Significant improvement in load pattern was observed on 2 x 210 mW units, 10 to 12 h after bunkering screened coal from Mazri and Ballarpur open cast mines.

Case 1

10 May 1993

(i)	Mazri Coal Rake received at Bhusawal TPS	17.30 h
(ii)	Bunkering started	22.45 h
(iii)	No.of boxes bunkered after screening	42 nos (2200 mtonne)
(iv)	Total screening fines, sand	132 mtonne (6%)

Case 2

19 May 1993

(i)	Ballarpur OCM coal rake received at Bhusawal TPS	58 boxes
(ii)	Bunkering started	16.35 h
(iii)	No. of boxes bunkered after screening	20 nos (1100 mtonne)
(iv)	Total screened fines, sand	65 m tonne (6%)

Case 3

31 May 1993

(i)	(a) Mazri coal rake received at Bhusawal	07.15 h
	(b) Bunkering started	09.30 h
(ii)	No.of boxes bunkered after screening load. It takes about 12 h to get effect of bunkered coal.	23 nos (1200 mtonne)
(iii)	Total screened fines	120 m tonne (10%)

In all the above cases the load on each 210 mW TA set improved to 150/160 mW, i.e., more than technical minimum load with considerably less percentage of coal reject as against previous load of 120/140 mW with higher percentage of coal reject, since most of the sand is removed in CHP, before bunkering of coal to coal mills.

Sand to the extent of 5 to 10% could be removed before the secondary crusher which otherwise would have added to the coal mill reject and caused damage to the Boiler Tubes.

Concluding Remarks

Availability of beneficiated coal at Mine end for use in the Thermal Power Stations has been *a topic of last two decades in our country and the Thermal Power Stations are facing insurmountable difficulties in handling inferior coal from Indian Mines containing large stones, shales, over burden, sticky fines, mud and sand* which contributes to additional ash percentage and becomes a main cause of forced outages of thermal units. Sandy coal with higher ash content is *one of the major killers of plant load factor* of the station due to frequent 'Boiler Tube Failures' and lower availability of on-line unit capacities.

An attempt is made here to solve the chronic problem by making use of low cost arrangement in Power Station and results achieved are found encouraging on account of the significant improvement in overall performance of thermal power station (Chart 1).

The above arrangement can be adopted in any thermal power station either before the secondary crusher or before the primary crusher by selecting tailor-made opening in the screen to separate specific size of fines and bypass desired quantity of fines depending on handling particular types of coal (Table 1).

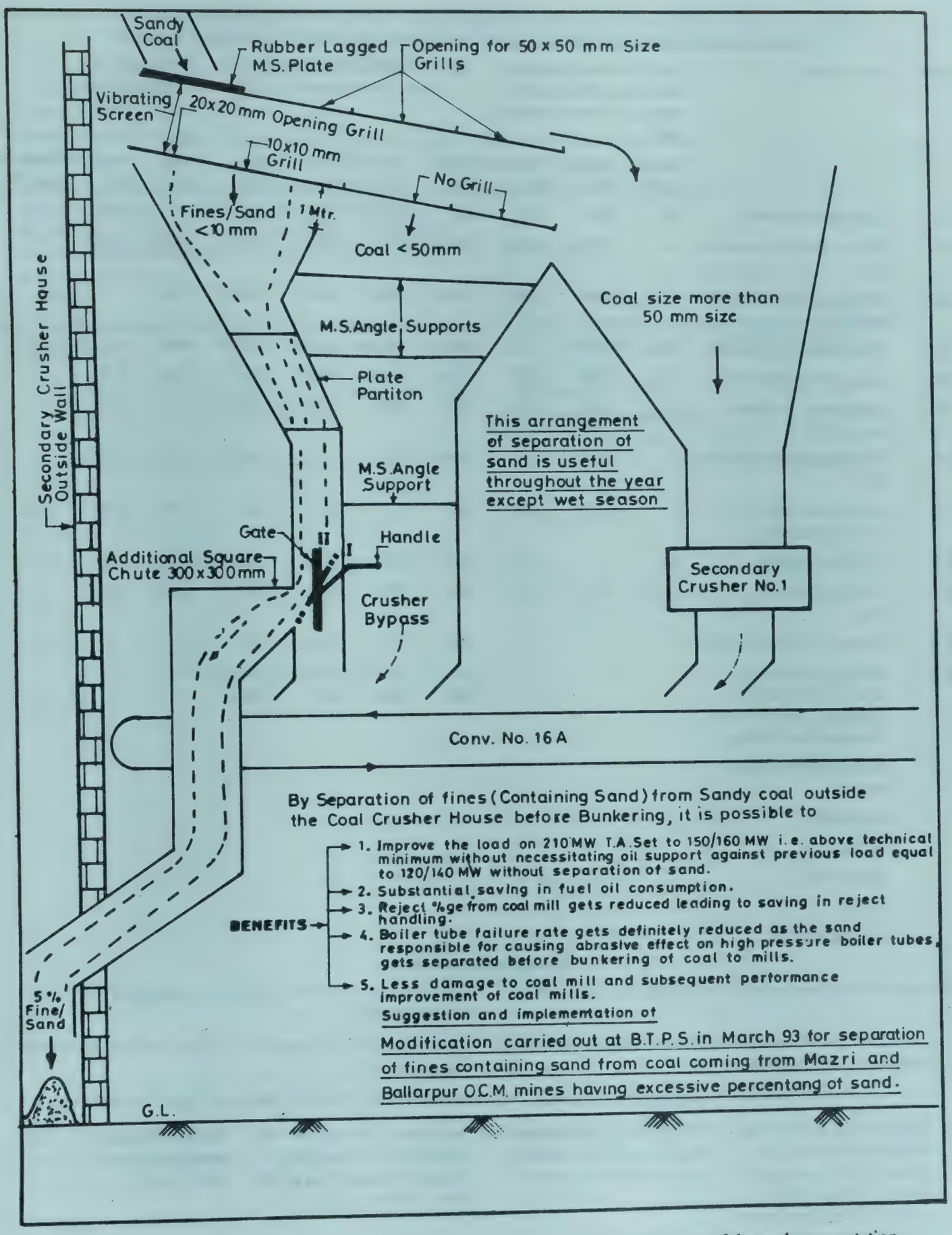

Chart 1 — Flow chart shows significant improvement in overall performance of thermal power station

Table 2 — Improvement achieved on account of screening of fines and sand from raw coal

Sl No.	Particulars	Use of raw coal without screening of fines and sand, i.e., effect of sandy coal	Effect of coal after screening fines and sand from raw coal					EFfect of wet coal problems		
		December 92	January 93	February 93	March 93	April 93	May 93	June 93	July 93	August 93	September 93
1.0	Generation in MW	203	255	213	267	250	259	261	181	212	—
2.1	Mazari Coal Received in MT	—	33931	44044	41979	27116	5919	9494	15679	6283	—
2.2	Ballarpur Coal received in MT	—	8896	27985	30233	30703	28971	11880	15679	—	—
2.3	Total Sandy Coal in MT	42827	72029	72212	57819	34890	21374	31358	6283	—	—
3.0	Coal cons.in lakhs MT	1.64	2.06	1.72	2.16	2.02	2.09	2.11	1.46	1.71	—
4.0	Sandy coal % of coal consumed	—	20%	41%	33%	28%	16%	10%	—	—	—
5.0	Coal Reject from Mills in MT	—	4635	4919	5616	5595	4117	5549	3197	3163	—
5.1	Coal Reject in (%) of coal consumption	—	2.25	2.86	2.6	2.77	1.9	2.6	2.19	1.85	1.85
6.0	Oil Rate ml/Kwh	8.4	3.3	4.6	2.57	2.8	2.06	1.9	6.4	5.4	—
6.1	Total fuel oil cons. (in KL)	1725	844	982	688	708	536	501	1170	1164	—
6.2	Saving in fuel oil (in Kl.)	—	—	—	294	274	496	481	—	—	—
6.3	Saving in fuel oil in terms of Rupees by screening fines & sands from coal in Rs lakhs	—	—	—	Rs 14.7 lakh	Rs 13.7 lakh	Rs 24.8 lakh	Rs 24.0 lakh	—	—	
7.0	Boiler tube failure per month										
	Superheater					1					
	Reheater			1							
	Water wall			1		1	1		2		
	LTHS		1								
	ECONOMISER		1	1							

Comparison / Benefits

Raw coal used as received at Power Station by doing nothing	*Coal used after screening of fines and sand from raw Coal received in CHP*
• Load on 210 mW could not be improved beyond technical minimum (120-140 mW)	1 Load on 210 mW improved to 160 mW without necessitating fuel oil support

Improvement in Generation by screening of sand and fines from 213 MU in Feb. 93 to 259 MU in May 93

• There were 3 Boiler Tube Failures in Unit 2 7 3 in February 93 However, after using screened coal, the rate of BTF reduced to one per month.	2 Boiler tube failure reduced in March, April, May, June 93, i.e. *to one BTF per month*	One Boiler Tube Failure Cost =Rs 6 lakh including High pressure welding, X- ray, DM water, F D for relightup, etc. +	Generation loss of 15, MU equivalent to Rs 2 Cr (for 3 to 4 d)

— Contd

Table 2 — Improvement achieved on account of screening of fines and sand from raw coal — (Contd)

• Coal reject percentage from coal mill increased to 2.86% in February 93 (from 2 to 4.68% in U-3 (3368 m tonne)	3 Coal reject percentage from coal		
• In February 93 the oil consumption due to poor coal quality was 655 KL for Station and overall specific oil consumption was 4.6 ml/kWh	4 Fuel oil consumption reduced in the month of March, April, May and June 93 from 4.6 al/kwh to 2ml/kWh		
Saving in Fuel oil consumption due to screening of fines and sand from coal		— 294 KL in March 274 kL in April 446 kL in May 481 kL in June 93,i.e. Saving of 386 kL/month fuel oil @ Rs 20 lakh/month	Monthly Saving of about Rs 20 lakh achieved

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CONFERENCE REPORT

Seventh National Symposium on Ultrasonics — A Report

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The seventh National Symposium on Ultrasonics was held during 6-7 September, 1996 at Mepco Schlenk Engineering College in the industrial town of Sivakasi, famous for its fireworks and printing industries. The Symposium was organised jointly by the Ultrasonics Society of India, New Delhi and Mepco Schlenk Engineering College, Sivakasi, which is a leading self-financing educational institution of our country. The theme of the symposium was 'Ultrasonic Technology in Support to Indian Industry'.

The symposium was attended by about 80 delegates from all over the country. Out of a total of about 80 papers offered for presentation, 50 papers were actually presented at the symposium. Besides contributory papers, a keynote address and eight invited lectures were also delivered at the seven technical sessions.

Inauguration

The symposium was inaugurated by Dr Placid Rodriguez, Director, Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam. Dr Baldev Raj, Head of the metallurgy and materials group in IGCAR and President of International Committee on NDT, introduced the chief guest. In his address, Dr Rodrigues underlined the importance of ultrasonics as a tool in various branches of science and technology including materials characterization, non-destructive testing, medical systems, underwater engineering, etc. Thiru A.Vairaprakasam, the correspondent of Mepco Schlenk Engineering College, while releasing the proceedings of the symposium, mentioned that the theme of the symposium " Ultrasonic Technology in Support to Indian Industry" was the need of the day. Thiru A Chelladhurai, chairman of the Metal Powder Company at Thirumangalam released the Souvenir. The keynote address was delivered by Dr J Prasad, Deputy Director, Aeronautical Development Agency, Bangalore. In his address Dr Prasad highlighted the non-destructive testing of composite materials which are increasingly being used in aircraft industry.

Earlier, while welcoming the delegates, Prof. G Shanmugam, Principal, Mepco Schlenk Engineering College, Sivakasi and Chairman of National Organising Committee, highlighted some of the recent developments in the field of ultrasonics. He informed that the symposium received sponsorship and financial support from many industries, leading research organisations and institutions. These included Metal Powder Company, Asia Matchworks, Ayyan Fireworks, Standard Fireworks, Sri Kaliswari Fireworks, Pandian Chemicals, AICTE, DST, DOD, CSIR, and TNCST. He also drew attention towards the messages of appreciation and good wishes received from (i) Prof. E S R Gopal, Director, National Physical Laboratory (ii) Prof. R M Vasagam, Vice Chancellor, Anna University, Madras (iii) Dr A P J Abdul Kalam, Scientific Adviser to the Defence Minister and Secretary, Defence Research and Development Organization (iv) Dr K Dharmalingam, Secretary, Tamil Nadu Council for Science and Technology (v) Prof. K Aludiapillai, Madurai Kamraj University (vi) Prof. P Balakrishan, Director, Technical Education, Madras (vii) Dr R Chidambaram, Chairman, Atomic Energy Commission and Secretary, Department of Atomic Energy. He regarded these messages as a measure of interest, the scientific community of India has in the field of ultrasonics.

Technical Sessions

The presentation of the invited and the contributory papers was organised in the following seven technical sessions: (i) Biomedical Ultrasonics, (ii) Underwater Acoustics, (iii) Ultrasonic Calibration Standards, (iv) & (v) Ultrasonic Propagation Studies: Liquid Mixtures, (vi) Ultrasonic Transducers and Materials & Ultrasonic Nondestructive Testing, and (vii) Ultrasonic Propagation Studies: Solids.

Biomedical Ultrasonics

The session had two invited lectures — one entitled "Echoes of 2000" was delivered by Dr V Amuthan (Cardiologist at Government Rajaji Hospital, Madurai) and the other "Diagnostic Medical Ultrasound — A Real Renaissance in the Turn of 20th Century" was delivered by Dr S Manohar (M/s Doppler Scans, Madurai). Both these talks were basically in the field of diagnostic ultrasound. The focus of the former lecture was exclusively on cardiography while in the latter, a general coverage of developments and applications of diagnostic ultrasound was made.

In his talk, Dr Amuthan described, with the help of colour slides, how the 3-D colour Doppler echoradiography has become a marvel of the twentieth century by its ability to diagnose most of the heart conditions. He mentioned that being low in cost, the echocardiography may replace the stethoscope in the office practice of cardiology in future.

Dr Manohar detailed the various conditions in almost all the branches of medicine and surgery where diagnostic ultrasound is playing a decisive role. Enumerating the advantages of ultrasound as a diagnostic technique, he explained that superiority of this modality over others includes its simplicity and safety, non-necessity of elaborate patient preparation, quickness and repeatability without the fear of ionizing radiation, cross-sectional imaging format with multitude of choices of planes of section. He also pointed out its poor penetration of air and bone, operator dependability, etc.

The contributory papers presented in this session included the papers pertaining to the ultrasonic investigations of animal proteins, namely collagen and casein (V Arumugam *et al.*, Central Leather Research Institute, Madras), tissue mimicking materials (Ashok Kumar *et al.*, National Physical Laboratory(NPL), New Delhi), and acoustical relaxation in aqueous amino acids (G Ravichandran *et al.*, Vellore Engineering College, Vellore).

Underwater Acoustics

In this session the invited talk was on "Application of Underwater Acoustics for Exploring Ocean Resources" (M Ravindran and V Rajendran, National Institute of Ocean Technology, IIT, Madras). In this talk, a review of acoustical exploration techniques used in fisheries to find fish species, shoal tracking and its classification were presented. The speaker also discussed the acoustic methods applicable to sea-bed surveys for mineral resources in shallow and deep waters. Among the contributory papers presented in this session were: 'Applicability of convergence zones in Indian waters' (M Sarangpani, Oceanographic Forecasting Cell, Kochi and Amit Vikram, Antisubmarine School, Kochi), 'Development of a 75kHz acoustic transponding device for underwater applications' (S K Jain and Reeta Gupta, NPL, New Delhi), 'Effect of geoacoustic parameters on the sea bottom reverberation' (P Balasubramanium and M M Muni, Naval Physical and Oceanographic Laboratory (NPOL), Kochi) and 'Seasonal variation of relaxation time and attenuation in marine sediments' (T Pradeep Kumar, NPOL, Kochi). In the presentation by Sarangpani and Vikram, the applicability of convergence zones in antisubmarine warfare for detecting the targets at longer ranges was highlighted while the paper by Jain and Gupta described the salient features of the newly developed transponding device. Through their studies Balasubramanium and Muni suggested that shear speed in sediments plays a major role in influencing the reverberation levels.

Ultrasonic Calibration Standards

The invited talk in this session was delivered by B S Sarma (Naval Science and Technological Laboratory, Visakhapatnam) on "Underwater Acoustic Transducers in Naval Weapons". In his talk, Mr Sarma presented a very lucid account of naval weapons, transducers' history, transducer materials and arrays as used in weapons. In this session the contributory papers were mostly related to ultrasonic calibration measurements. These included 'Stable quartz crystal frequency generators for ultrasonic applications'(D S Sachdeva and V R Singh, NPL, New Delhi), 'Power press impact measurement'

(Shanta Sondur, Government College of Engineering, Pune), 'Automation of initial setting time determination for concrete by ultrasonic pulse velocity measurement' (M S Palanichamy *et al.*, Mepco Schlenk Engineering College, Sivakasi) and 'IGCAR's experiences in ultrasonic attenuation measurement' (P Palanichamy, IGCAR, Kalpakkam). Two papers were related to high frequency ultrasonic spectrometer based on light diffraction (G Radha *et al.* and Gopi Krishna *et al.*, Osmania University, Hyderabad).

Ultrasonic Propagation Studies — Liquid Mixtures

Two invited talks were delivered in this session — one by Dr (Mrs) A Dhanalakshmi on "Spectroscopic Significance of Internal Pressure in Aqueous Electrolytes" and the other by A Srinivasa Rao on "Ultrasonic Studies on the Formation of Hydrogen Bonds in Solutions". In her talk, Dr Dhanalakshmi presented an authoritative exposition on the fundamental importance of the internal pressure, as evaluated from ultrasonic properties, in explaining the molecular properties such as proton lattice relaxation rates, etc. in electrolytic solutions. The other invited talk reviewed the formation of hydrogen bonds in solutions using ultrasonic velocity and absorption measurements.

This section received the maximum response and some twenty papers were slated for presentation, out of which about three fourths were actually presented. These related to aqueous solutions of electrolytes such as strontium chloride (Pia Thomas and Gandhimathi, Holy Cross College, Trichy), quaternary ammonium salts (A Dhanalakshmi *et al.*, Seethalakshmi Ramaswami College, Tiruchirapalli), sugar alcohols mannitol and inositol, and lactose (A Dhanalakshmi *et al.*), bromobutyl rubber (J F Rajasekaran *et al.*, Madras Christian College, Madras), etc.

Studies on other liquid mixtures included binary mixtures with components such as ethylene glycol in tetrahydrofuran, polyethylene glycol in aprotic solvents, polyvinyl pyrrolidone in N,N-dimethyl formamide (B. Dominic Joshua *et al.*, Pondicherry University, Pondicherry), cholesteryl oleyl carbonate - cholesteryl chloride in liquid crystals mixture (M L S Swamy *et al.*, NSTL, Visakhapatnam), 1,1,1-trichloroethane, n-octane in 1- alcohol (U Srinivasulu and P R Naidu, S V University, Tirupati), *o*-chlorophenol (G V Ramarao and A V Sarma, Andhra University, Waltair), mixtures of ethyl acetate with alkanols (P S Nikam *et al.*, M S G College, Malegaon Camp), aceto (and benzo) nitrile in methanol (Roshan Abraham, M G University, Kottayam),etc. Other papers presented in this session related to the study of excess thermodynamic parameters of binary mixtures of monoalcohols (J Poongodi *et al.*, Mepco Schlenk Engineering College, Sivakasi), benzene, cyclohexane and carbontetrachloride (D Veerbhadraiah, S K D University, Anantpur).

Ultrasonic Transducer Materials and NDT

The invited talk at this session was delivered by Dr Baldev Raj (IGCAR, Kalpakkam) on "Ultrasonic Non-destructive Evaluation of Defects, Microstructures and Residual Studies". In this interesting talk, recent developments in computer-aided ultrasonic NDE for high sensitivity defects sizing and characterization were outlined. These included techniques such as time of flight diffraction, synthetic aperture focussing, acoustic microscopy, split spectrum processing. Application of the techniques by the authors in defect sizing and characterization of austenitic steel, 9Cr-1Mo steel, weldments, etc. were also highlighted.

The contributory papers presented on ultrasonic transducers were mostly from NPL, New Delhi. These included 'Design criteria for a flextensional low frequency transducer' (S K Jain *et al.*), 'Measurement of aluminium in quartz crystals by near infrared absorptions' (Harish Bahadur), 'Piezoceramic elements for high frequency transducers' and 'Electromechanical parameters of piezoceramic materials at high hydrostatic pressures'(J Singh *et al.*), '1-3 piezocomposite hydrophones' (C Durgaprasad *et al.*, Naval Materials Research Laboratory, Mumbai).

The papers in the session on ultrasonic nondestructive testing included 'Performance characteristics of NDT transducers (Yudhisther *et al.*, NPL, New Delhi), 'Ultrasonic imaging systems for NDT/NDE of metallic parts' (V M Joshi, Bhabha Atomic Research Centre, Mumbai), microstructure characterization of β-quenched and thermally aged zircaloy-2 (T Jayakumar *et al.*, IGCAR, Kalpakkam), 'Bubble counting in neutron bubble dosimeter' (D Ponraju *et al.*, IGCAR, Kalpakkam), 'Life predic-

tion of power plant components' (S Ravichandran and K A Shaik Alaudin, Regional Engineering College, Trichy).

Ultrasonic Propagation Studies — Solids

Dr J Phillips from Cochin University of Science and Technology (CUSAT), Kochi, delivered the invited talk at this session. The topic chosen by him was "Ultrasonic Study of Ferroelastic Phase Transition in Solids: Application to Lithium Ammonium Sulphate (LAS)'. In his talk, Dr Phillips explained the pulse-echo overlap technique for accurate determination of ultrasonic velocity and attenuation. Taking LAS system as an example, it was shown that the technique can be effectively used to study the ferroelastic phase transitions in solids. The contributory papers presented in this session were 'Absorption coefficient of some Indian igneous rocks' (C Srinivasa Reddy and D Linga Reddy, Osmania University, Hyderabad), 'Elastic properties of $(Zr_{0.8}Sn_{0.2})Ti_{1-x}Hf_xO_4$) ceramics' (N Rodrigues and J Phillips, CUSAT, Kochi), 'Evaluation of macro and micro structures and mechanical properties by ultrasonic testing techniques' (N M Jha, National Institute of Foundry and Forge Technology, Ranchi).

The Symposium ended with a valedictory function presided over by Dr K Dharmalingam. In his valedictory remarks, he expressed the hope that the delegates must be feeling rejuvenated with the new ideas that they are taking back with them sweet memories about the event held at Sivakasi.

A General Body meeting of the Ultrasonics Society of India was also held at which the election results for the new executive council were announced. Prof. E S R Gopal (Director, NPL) was re-elected for another two years as President of the Society.

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BOOK REVIEWS

Environmental Policy With Political and Economic Integration— The European Union and the United States, edited by John B Braden, Henk Folmer and Thomas S Ulen (New Horizon in Environmental Economics Series, General Editor: Wallace E Oates) (Edward Elgar, Cheltenham, UK) 1996, pp 488, Price: £ 59.95 (hb)
[ISBN 1 85898 247 O]

One of the most fundamental issues of environmental policy in the context of a federation (e.g the United States) or confederation (e.g. European Union) is how the decentralization that is desirable because of regionally different physical systems and social values can be reconciled with the existence of environmental externalities that imply the need for central environmental policy and enforcement. Such a reconciliation is achieved through both European directives and American policies that leave the state law in place or affirmatively delegate law making to the states.

The authors have made an endeavour to develop some hypothesis by comparing various environmental policies and practices in the United States (US) and the European Union (EU) with respect to: (i) what is the most appropriate level of environmental policy- making in a federal/confederal system, (ii) is there a need for harmonization of product norms, product standards and technical regulations by the federal or central government in order to further environmental goals, and (iii) how does the level of government at which policy is made and implemented affect the choice of policy instruments.

The book consists of five parts. Part I (The Economic and Philosophical Foundations of Environmental Policy) provides a comparative overview from an economist's point of view and presents the fundamental moral and ethical justifications for environmental policy.

Part II of the book (The Law and Economics of Authority in a Federal System) propounds a comparative assessment of regulation through the agency of member states in the US and the EU and also contains an economic analysis of the most efficient division of responsibility for environmental policy in a federation.

Part III (The Political Economy of Instrument Choice) reviews both the positive and normative literature on the choice of instruments as it applies to environmental policy and points out how matters of strategic behaviour are likely to affect plant location choice.

In Part IV (International Trade and Environmental Policies), the linkages between trade and environmental policies as well as the general policy issues that arise at the intersection of environmental concerns and a liberal international trade regime are examined.

Part V (Case Studies of Comparative Environmental Policies) contains several case studies that shed light on the research questions mentioned earlier in the second paragraph. The case studies concern the most important global environmental problems of the present time, viz. agricultural pollution, global warming, tropospheric ozone pollution, and environmental dimensions of national and international security.

On the whole the book is very comprehensive and well-written and likely to be referred continually by those concerned about the environmental policy matters. Each chapter has an extensive list of references for the interested reader to pursue topics of special interest.

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Human Resource Needs for Change in R&D Institutions, edited by M A Qureshi (World Association of Industrial and Technological Organizations and National Institute of Science, Technology and Development Studies, New Delhi) 1996, pp xxii+296; Prices: Not mentioned
[ISBN 81 7236 131 9]

The globalization of economies which is underway now, offers many challenges, especially to the developing countries. Perhaps the most important challenge is that of modernization of human resources, at the managerial, worker and academic levels. The developing countries as a whole would need to substantially upgrade their human resources without which they will not be able to attract investments. The larger countries such as India and China which have already built up a substantial industrial and R&D infrastructure have the additional task of modernizing their R&D organizations to meet the challenges posed today.This is a more difficult task than the upgradation of technical knowledge of workers, experience in using sophisticated machines or even developing financial and investment skills, as it involves the development of creativity and originality . These are not tailor made and may involve the remaking of entire societies. While the experience with science and R&D for countries such as India and China may give them more scope and confidence for the reorientation of their R&D systems, the very size and inertia of the system makes their tasks more difficult. The volume under review offers some suggestions on how this difficult task can be accomplished. .

The twenty-four papers comprising this volume were originally presented at an international conference jointly organized by the World Association of Industrial and Technological Research Organizations (WAITRO), the National Institute of Science, Technology and Development Studies(NISTADS),New Delhi, and the Sri Ram Institute for Industrial Research(SRI), New Delhi. The first is an association of more than one hundred R&D organizations, from both the developed and the developing countries which have successfully performed on the interface between R&D and industry. It has held seminars on the themes such as new technologies, industrial reorganization, international cooperation in R&D etc.The second is one of the major policy oriented institutions in India, and the third is a premier R&D organization funded mainly by the private sector, and having many commercially successful processes to its credit. The three organizations together offer expertise and experience which would be difficult to match, which is reflected in the comprehensiveness and quality of the papers. The papers included in this book are grouped in seven major areas: (i) Policy Dimensions (ii) Dynamics of R&D institutions, (iii) The Human Resource Perspectives in R&D, (iv) The culture of R&D institutes, (v) International cooperation for HRD, (vi) National R&D policies and, (vii) Bench marking of best practices.

While it may not be possible to discuss each paper in this review,an outline of the major discussions on the themes are given. The first topic discusses how R&D can be reoriented to become compatible with the requirements of industry, maintaining at the same time their creative edge. Examples are given of the CSIR as well as the Saskatchewan Research Council, Canada.The latter organization started as a university grants agency and has now evolved into one of the most dynamic and successful of research organizations in that country. The second theme, on the dynamics of research organizations, discusses the conditions under which industrial firms and technology institutions (TIs) interact, in the context of the new paradigms of innovation and entrepreneurship,and of informal information and knowledge networks. The dimensions of strategic change to meet the new requirements should focus first of all on retaining the skills of experts in their areas of expertise, rather than losing them to general management functions.At least during the initial stages, a process of optimization of skills and services may be needed before launching onto major new products.

The third theme, relating to human resources perspectives, stresses the components of continuous learning,individual development, and supportive organizational climate. All the papers are from India, and the specific examples of microbiology, agricultural sciences and general biology are considered.An interesting paper deals with the difficult problem of providing quality assurance in higher education,especially in areas such as engineering, science and medicine. Higher education has become a mass phenomenon, with institutions of varying quality and the customer has to have a process whereby he can rely on the value and up-to-date quality of the education provided. It is suggested that this can be done by a program of accreditation, whereby an institution periodically evaluates its activities and submits itself to a judgement by peers on whether it is meeting established standards. The process has become standard

in many advanced countries especially the US, but it is new in the Indian context. It has to be an entirely voluntary process at least for the time being, as funding agencies such as UGC have at present no legal authority for mandatory accreditation.But they 'encourage' the process, and it is suggested that the students themselves should press for its adoption, as they have an interest in seeing that their degrees carry value.

The next section examines the mechanisms that enable a supportive organizational climate to be built up. The task is difficult, especially in the context of the developing countries. Industrial technology research institutes (ITRIs) in the developing countries face a lot of problems in becoming relevant to the industry in their countries, in updating their knowledge and skills, in dealing with new problems such as those relating to environmental protection, and in coping with reduced governmental support. While the issues facing individual institutions may be particular to themselves, a general advice is given on how to accomplish the reorientation, which includes an analysis of the governmental policy context in which the institution operates,critical evaluation of the needs of the clientele,attracting more and better funding, cooperation with other national institutions ,developing of adequate performance indicators, etc.

Cooperation with other institutions can be at an international level also, and while there are no programs for extensive institutional collaborations with shared research agenda,some programs exist for collaboration and personnel training.Countries such as Denmark, the Netherlands, the UK and the US offer substantial programs of assistance and training, and WAITRO itself takes an initiative in organizing collaborative programs among its members. But there can be drawbacks in this area as well, as exemplified by the experience of Ghana, in which expensive programs of postgraduate training outside the country have resulted in not tangible gains for the country's R&D system, at least commensurable with the costs incurred. There is need for a considerable upgrading of local programs for training at graduate and postgraduate levels and ensuring compatibility of training received outside with the needs of the national research system.The national R&D context is also of critical importance and the next section deals with this major theme.In India the large expansion in the research system has not been matched by a similar commitment to quality, and the poor linkages between components of the research system such as academics, governmental decision makers, industry and the financial sector makes it difficult to have optimal utilization of the facility that exists. While improving performance in this area, the possible trends in technology have to be anticipated for the national research system to take up productive research areas. The situation in the former USSR in the current difficult circumstances also comes up for discussion, although without offering any real solutions.

The last theme is benchmarking, a process of comparison of practices between organizations to select the best out of them. WAITRO has a major project on this topic, and the papers present some of the results. In one of the papers, five Canadian firms are compared in terms of objectives, the methodologies or processes adopted to attain them, critical success factors, key performance indicators, etc. In another, the best practices of eight organizations , four from India, and one each from Sri Lanka, Singapore , Thailand and Malaysia are examined, and macro indicators such as growth of income from clients, ratio of government grant to income derived from clients,and expansion programs are examined . Best practices in several areas such as project evaluation and marketing, capability upgradation, services mix are also analyzed.

The book on the whole is an excellent contribution to the important area of human resources in R&D. It would probably be very useful to individual scientists as well as institutional R&D managers on the practices to be followed. But it leaves some major issues unexamined, with a bearing on why there search system in the developing countries does not make adequate contributions to national industry. Some of these have to do with the nature of the scientific work itself. The high degree of uncertainty in scientific work , especially when it has to be creative and come up with novel applications or processes, clearly differentiates it from the work in mass production industries and in the administrative spheres. It follows that control over the work processes in sciences can be exerted only by the workers themselves and not by external authority. The scientific workers model

their work on the "best practices" that they can observe in actual practice , and try to reach them .In the developing countries, by and large this means published information in journals , which are mediated by the reputational system that academic science normally follows. If industry requires that there searchers apply themselves to the problems industrial importance,they should have access to the best practices in this field, and they should be intimately and continuously involved in the industrial process. Thus the best results in industrial research occur in countries where the general level of industry matches with the problems that are of current scientific interest in the academic system. In the developing countries, where the general level of industrial problems sharply differentiate it from the academic sector, it may be better to have large technology import programs and to focus R&D attention on the assimilation of the information thus acquired. This would mean a rather drastic change in the R&D system. Without this, it is doubtful whether any amount of bench marking and other HRD practices can yield the expected results.

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SCI-TECH UPDATE

Academic notion of peer review under trial

Two biotech companies, Cistron Biotechnology of Pine Brook, New Jersey, and the Immunex Corp of Seattle are involved in a legal battle to fight out over the right of academics to keep manuscript secret while they are undergoing peer review.

Cistron says that in 1984 an Immunex scientist shared data on an immune-system protein with his colleagues who then used the unpublished information in their own research and patent applications. The paper is contributed by an academic consortium funded by Ciston which was in close competition with Immunex. Both companies have put forth their arguments and an impressive line of witnesses including eminent people—Nobel laureates, editors and academicians. The judge presiding over the case limited the scope to questions of trade secrecy and "unfair competition".

Cistron filed its law suit about 3 years ago, but the dispute behind it goes back to 1980s when Cistron and Immunex scientists were racing to isolate and patent a protein called human interleukin-1 (IL-1). Philip Auron and colleagues from Cistron sent a paper claiming to have isolated the human DNA coding for IL-1 to *Nature* in December 1983. It was sent to Steven Gillis of Immunex for review for which Gillis sent a negative report. Gillis sent a confidential note to *Nature* saying that his team has independently isolated IL-1, and that his data proved Auron Wrong. Cistron's argument hovers around the theme that Immunex behaved unethically and "misappropriated" a trade secret when they filed a patent containing Auron's data.

Immunex responded to the barrage of Cistron's outrageous remarks with the following observations. It said that academics who receive public grants are categorically excluded from holding trade secrets under provisions of the Bayhdole Act, a law that aims to promote the transfer of technology to private hands. It further said that anyone who sends a manuscript to a journal has automatically surrendered trade secrecy protection through the act of submitting for publication. Moreover, Immunex claimed that the guidelines for handling manuscripts under review are so variable and vague that there is no clear-cut, uniform rule about what a reviewer is or is not supposed to do.

Cornells Gregory Siskind, a professor of medicine and associate dean for research and sponsored programs at Cornell University Medical College in his expert report for Immunex feels that Auron and his colleagues cannot keep their paper as secret as their research is based on university based, publicly funded project. As far as the Cistron attack of unethical conduct is concerned he argues that Immunex scientists had not violated any rule or any uniformly accepted standard code at that time as he pointed out "there are no codes, standards, or rules governing journal peer review which are generally accepted by all groups in the biomedical community".

The verdict of the court will be undoubtedly be eagerly watched by the collective group of authors, sponsors, editors and publishers [*Science*, **273** (1996) 1162-64]. ❑

DSRM

Software summarizes text

A computer programme called 'Netsumm' which summarizes text has been developed by the BT's research Centre at Martlesham. Presently existing as a prototype, the software can reduce page of text into paragraphs or sentences and will be demonstrated soon to city dealers. The dealers will use it to draw out key elements from detailed company report.

The software is currently being tried on the Internet, but a stand-alone version for use with MS Windows will also be developed. The software is the outcome of general complaint that in modern computer and communications field, people are bombarded with information which is proving difficult to cope up with volume. The software aims at reducing the "textual intimidation" by using statistical methods to summarize a given text. Any plain-text document can be an input to Netsumm and automatically

picks out the important sentences of text [*Electron Wrld*, **102** (1725) (1996) 638]. ❑

DSRM

New dye may enhance data storage on compact discs.

Presently available CD-ROMs store data on their surface which can accommodate upto 600 Mb. To increase the capacity of data that can be used with a computer, jukebox arrangement is also prevalent so that about 10 times the capacity can be achieved.

But according to Paras N Prasad, Professor of Chemistry, Director of New York University of Buffalo (UB) Photon Research Laboratory and Principal investigator, a novel dye developed by them will enable them to considerably augment the storage capacity of compact discs. This dye developed at UB exhibits a strong two- photon absorption as well as strong fluorescence emission. The dye is planted with transparent plastics to form the storage medium. The data are stored by focussing the laser to alter the properties of the material. The main breakthrough is to store data not on the surface but in stacks like pages of a book allowing data to be stored in the depth of a disk. At an American Chemical Society meeting, the "read" (playback) of a cartoon film was demonstrated. Several seconds of the film were stored in a cubic volume, each side of which was the thickness of human hair [*Ind Week*, October 7, 1996, p. 41].❑

DSRM

Intergraph doubles graphics performance

According to J David Farmer at the Intergraph, Huntsville, AL, USA, off-the-shelf components and industry-standard architecture have helped it to deliver more graphics bang for the buck compared with RISC/UNIX workstations. Intergraph is leveraging the PC market to get the costs reduced.

The company's latest TDZ 3*D* graphics workstations use one, two, or four Pentium processors, and feature built-in 100-Mb/s Ethernet networking. Intergraph's new RealiZm graphics system is the first to offer 2.5 million triangles/s. This more than doubles the performance of Intergraph's earlier generation of graphics while shrinking the subsystem from a deskside tower down to a single board.

One animation demo that took 12 min on an older system ran in just 6s on the new TDZ. This technology is likely to change the mechanical design process, allowing researchers to work on more complicated models interactively.

Three different graphics configurations—th Z10,Z13, and Z25—feature from 1 to 2.5 million triangles/s, with optional texturing and geometry acceleration.

The RealiZm graphics system is a 2-PCI-card set bundled together as a single board. It uses three different types of custom- designed chips, for the bus, main geometry-acceleration engine, and memory interface. The largest ASIC, for graphics acceleration, features more than 400,000 logic gates and presents special design challenges because of its size.

To deal with the different heat-expansion properties between the packaged chip and the board it sits on, researchers designed in "stilts" of solder-like material and flex so the board can expand without stressing solder joints. This allows the board to be sold as an OEM product, to be placed in machines that get hotter inside than the TDZ.

The TDZ310,410, and 610 workstations are priced starting at $9,995 for a uniprocessor 200-MHz version with RealiZm Z-10 graphics, 32 MRAM, and 1G hard drive [*Des News*, **51** (14) (1996) p. 40]. ❑

HKK

High-speed imaging system

Southwest Research Institute has acquired a ultra high-speed imaging system which works faster than speeding bullet and records up to six frames at a rate of 100 m frames/s. This imaging system is first of its types in the US

According to John P Riegel, Manager of Ballistics Engineering in SwRI's Materials and Structures Division, the new camera is being applied to ballistic events that range from simulated bird impacts on aircraft to evaluations of spacecraft shielding effectiveness against orbital debris. Both cases illustrate the use of ballistics research to help prevent loss of life and millions of dollars in damage.

The IMACON 468 system has exposure durations as short as 10 ns, or 10 billionth of a second. To illustrate the incredibly fast speeds involved in some events, Riegel explains that a specially designed shaped charge is used to produce a projectile that moves 36.000 ft (about 7 miles) in one second when launched. The projectile, which depends on technology used by the military, is used to stimulate impacts on spacecraft. With the new camera, the projectile

moves only four-thousands of an inch during each exposure, making it possible to obtain critical information about the projectile and its effects on proposed shielding materials.

The imaging system relies on microchannel plate intensifiers and charged coupled devices to create images, which are transferred to a PC through fiber optic cables for electronic processing. The transfer takes about 2 s, making images available for viewing immediately following a test [*Technol Today*, **17**(1) (Spring 1996) p.23]. ❑

HKK

Police touchscreen system to help fight crime

Researchers at the British Telecom, Olivetti, UK, and the London Metropolitan Police Department of Technology under the AdvancedTranseuropean Telematics Application for Community Help (ATTACH) multimedia project, a European funded consortium have developed a Customer Service Terminal (CST) which will help to deal with crime and provide a range of other essential services to the public. The equipment is linked to a £ 4 million computer.

The CST system comprises a terminal featuring a touchscreen, stereo speakers, printing unit and a telephone handset with multimedia application software which has been developed to meet police requirements, all specially designed for ease of use.

The touchscreen technology will enable people who are not familiar with computers to be able to use CST in public buildings to report incidents. There are interactive facilities for help and immediate feedback, as well as access to translation in foreign languages.

The system's video, audio and data interface allows users to browse through information easily and, when required, connect to a central police station or a remote expert via an audio phone call or speak face-to-face with a police officer via an inbuilt videophone. Members of the public will be able to get counselling and local information services as and when required.

The equipment is expected to ease pressure on the police who are working within strict budgets without compromising on the levels of service and protection they provide to the community.

The system, which is installed in the Borough of Newham that has a high ethnic minority population, can also supply information in up to ten languages, have access to police and local authority assistance, as well as information about missing persons and details of local anti-crime initiatives.

The potentials for other related services are almost limitless. They include third-party information services such as Talking Pages, emergence services AA and RAC, Childline, Dragline and the Anti-terrorist line. It will even allow motorists to produce deriving documents through a digital image linked to the police station [*Spectrum*, **No. 255** (1996) p. 2-3]. ❑

HKK

Infrared imaging helps drivers to have a distant view of road

It is in fact said that a major part of the modern automobile is devoted to electronics that make the drivers' job comfortable, safe and secure.

At night the driver is usually assisted by powerful lights to have a clear view ahead on the road.

Texas Instruments have developed a system called *Night sight* that will reveal the road ahead for three to five times further than what is possible by now while driving fast in the night. The system uses a thermal imaging cameras and heads-up-display (HUD) technology to project a picture of the road ahead into the driver's field of view.

The system uses a Delco Electronics HUD to project real-time thermal images onto the lower section of the car's windscreen. The infrared image is translated into a high-contrast video image which is displayed in the same perspective as the driver's own vision. The result is a superimposed view of both of them through the windscreen. Thermal imaging helps the driver of separating people, hazards and other objects from cluttered backgrounds in full daylight or total darkness. The use of infrared technique enables it to avoid the inconvenience of 'bloom' or shutdown when hit directly by visible light of the headlights of vehicles coming in the opposite direction. Similar technology is used to some extent by the military and police. Texas Instruments is hopeful that this system when fully developed and applied in practice, could prove to be as important as the air bag and may reduce the driving fatalities that happen in the night [*Electron Wrld*, **102** (1175) (1996) 643]. ❑

DSRM

Ultrasonic gauge for quick inspection of bridges

Corrosion inspections on bridges are time-consuming and difficult tasks for inspection personnel. Particularly on motorways and busy trunk roads this poses problem where disruptive lane closures are a major traffic hazard. Moreover, speed is vital for the thickness measurement checks which are normally done on decks, parapets and arches.

Terry Rogers, Surrey County Council's senior bridge inspector says that with the presently available thickness measurement equipment, they had to grind off the black bitumen coating and even sometimes drill down through the road surface to check metal thickness at key points. Also this procedure requires additional equipment - a compressor to power the grinder, a generator and associated cables for lighting if on night-time working. The existing ultrasonic equipment needed a separate oscilloscope adding to the bulk of the auxiliary equipment.

Cygnus Instruments Ltd have come out with what is called Cygnus, a light weight, portable, multiple echo ultrasonic thickness gauge which enables the inspection personnel to take very fast, accurate and fail-safe thickness measurements with minimum disruption and no extra equipment. Rogers said that the new gauge is very useful on Corten steel because there is no need to grind away the surface rust. The inspection personnel only need a pair of gloves to wipe away the loose rust prior to taking readings. Each measurement takes only few seconds compared with several minutes before. It thus enables the personnel to quickly finish the inspection and remove the mobile underbridge unit with minimum disruption to the traffic. Also, the convenience of the Cygnus minimizes the time to be spent near the very dangerous and busy carriage-way. The new gauge is able to measure, on some older wrought iron bridges in UK, web and flange thickness on 23- m span bridges in just few hours, as against the previous time of about two days.

The Cygnus Instruments range of thickness gauges includes the Cygnus I Basic, intrinsically safe and underwater models, the Cygnus 2 standard model and the Cygnus 3 which interfaces with a Psion oraniser for data-logging. All thickness gauges in the Cygnus range use the multiple-echo ultrasonic technique which improves the accuracy and prevents false readings [*Insight*, **38** (11) (1996) 772-73]. ❑

DSRM

Light weight easy-to-use defibrillator

Automatic External Defibrillator (AED) is used by police officers, lifeguards, and others who respond to medical emergencies to save victims of sudden cardiac arrest (SCA). Conventional AEDs require daily maintenance, are bulky (~ 20 lb) and are costly. They require an operator to remember a treatment protocol and frequent retraining to maintain skills is required.

Heartstream Inc. reported a relatively low cost AED that weighs only 4 lb. and is easy to use. Known as Forerunner AED, the new defibrillator contains advanced algorithms and lightweight battery technology. Carl Morgan, Vice President of the R&D at Heartstream Inc. expressed that they tried to bring to the party an ability to automatically tune a biphasic waveform and optimize it for each patient on the fly.

Since Forerunner uses a biphasic signal, engineers need to store less energy within the device. Hence non-traditional battery technologies are used—single six-ounce high-energy-density Li battery. This battery can perform about 100 shocks. There is a built-in mechanism to alert the user to a low-battery status.

The unit does some preliminary things automatically when it is switched on, e.g. a voice chip informing the user how to connect the electrodes, and on connecting the electrodes an ECG is taken and if multivariable signal processing analysis indicates the necessity that the patient should undergo defibrillation, a microprocessor activates the shock circuitry. It then tells the user to shock the patient. The system charges up a 100 F capacitor to about 1800 V and then discharges it across a pair of electrodes on the patient's chest. Data collected from the patient determine the width of the pulse delivered in the biphasic discharge, the total pulse duration of the wave, and the amount of energy delivered. The defibrillator then switches to a monitoring mode, and determines whether or not the patient's heart is beating properly. The system also contains a removable PC card to store voice data of half an hour duration, ECG data, and operator actions which can be taken from the site for further use.

Heartstream tried the system at 14 sites covering about 300 patients, and FDA approval is awaited. Expected cost ranges between $ 3050-4000 [*Des News*, **51** (8) (1996) 54]. ❑

DSRM

Modified trees clean up paper industry

Researchers at the US Department of Agriculture and North Carolina State University, USA, have found a way to modify the structure of lignin to make it less problematic.

One of the three hydrocarbon monomers that make up the lignin molecule causes most of the problems in pulp making and animal feed. The gene in maize plants that encodes the troublesome monomer has been found. It is hoped that by altering the plant to deactivate the gene, the plant's lignin shall be easier to process or digest.

There will be numerous potential benefits. For example, European farmers feed maize stalks or silage to animal herds for feed. Maize with a mutated version of the gene would be easier for the animals to digest and would therefore be more nutritious. Altering the gene in trees could clean up paper making. The biggest environmental damage during paper making is in getting the lignin out.

There will also be huge economic advantages. Earlier research at North Caroline in 1988 estimated that cutting the lignin in trees by 5% would save $100 million per annum for paper making. Modified trees would still grow upright [*New Sci*, **153** (No. 2066) (1997)]. ❑

HKK

Protecting books against theft

Researchers at the P P Payne Limited, Giltway, Giltbook, Nottingham, UK, a specialist British packaging company have developed hidden electromagnetic security tags, applied automatically and at high speed into the spines of books during the printing process. This will help book sellers to guard against theft.

The system called *Tagax system* comprises a continuous electromagnetic tape, a dispenser and an applicator head. The 6 mm wide, continuous pressure-sensitive tape is traverse-wound in lengths up to 25,000 m to deliver more than 3,00,000 discrete switchable tags, either dormant or activated, during the manufacture of casebound and paperback book at full production speeds of up to 25,000/h.

For the retailer, the system offers built-in, reliable, covert and switchable security. Books are supplied with the tag already in place, and the appearance of the product remains unchanged, making detection of the tag virtually impossible. Activation, deactivation and detection are achieved using existing electromagnetic equipment.

Printers need not make changes in the manufacturing process as the system 'bolts on' to printing equipment. The system has been tested successfully by two leading book printers at full line speeds, with little disruption to the manufacturing process.

The Tagax source-tagging system is a result of needs identified by Britain's Book Industry Communication (BIC), to develop a system to combat book theft in retail outlets. CD and CD-ROM and food retailing sectors are also expected to take up the technology [*Spectrum*, **No.255** (1996) p.4]. ❑

HKK

Mechanism of soap browning uncovered

Chemists at the Japanese cosmetics giant Shiseido, Yokohama have reported why triethanolamine (TEA) soaps turn brown on storage in warm environments.

Manufacturers of personal care products favour such soaps as triethanolammonium laureate for their quick foaming, dense lather, and good low-temperature solubility. But the down side for cosmetics is the gradual colour change.

The samples in accelerated aging tests at 120°F smelled faintly of aldehyde and amine. Researchers followed up that tip with studies that show that TEA decomposes to ethanolamine and two mol of acetaldehyde.

Acetalydehyde then condenses to form crotonaldehyde. Crotonaldehyde forms a Schiff base with the ethanolamine. And finally, the unsaturated Schiff base undergoes 1,4-polymerization to coloured products [*Chem Eng News*, **78** (38) (1996) p. 42]. ❑

HKK

Iridium converts strained olefins into adhesives

Katherine A Brown *et al.* at 3 M St. Paul, Minn, USA, have developed a versatile reaction catalyzed by iridium which easily converts strained cyclic ole-

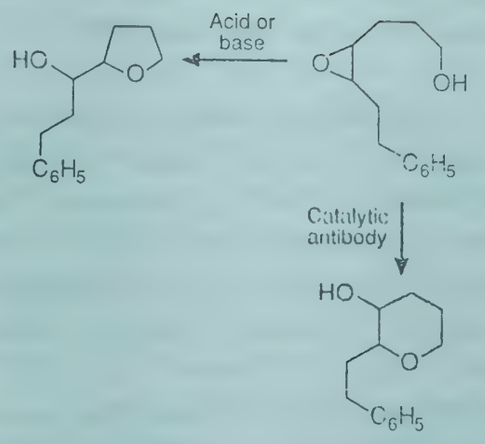
fins such as norbornenes to rubber like polymers that can be used as adhesives.

Under various conditions, low levels of iridium-based catalysts such as [Ir(cyclooctadiene)Cl]$_2$ produce quantitative yields of high molecular weight (1 million) polymers. The iridium catalysts are robust — active at 0 to 100°C and tolerant of additives. The reactions proceed more rapidly in air than in an inert atmosphere, an advantage for batch reactions and in-line processing. An example of a typical formulation includes the monomer 5-hexyl-2-norbornene, tackifiers, the catalyst, and the co-catalyst $Zn[N(SO_2CF_3)_2]_2$ at a ratio of 345:260:1:1:4 by weight. The formation is coatable for hours at room temperature. When the mixture is applied to a polyester backing at a thickness of 75 μm, polymerization is complete within 2 min at 116°C to give a pressure-sensitive adhesive [*Chem Eng News*, **74** (38) (1996) p. 42]. ❑

HKK

Theozymes: new concept for predicting catalytic activity

Jim Na and Kendall N Houk of the University of California (UCLA) are exploring a different way of studying how enzymes bind their substrates. Catalysts boils down to stabilizing short-lived transition states, but there is no direct way to study how they bind.



The UCLA chemists are taking the computational route, by "guessing" functional groups that stabilize the transition state, verifying the guess by quantum mechanical calculations at a level of theory that gives reliable energetics without calibration, and comparing the results of theory with experiments.

Using the theozyme technique, researchers have explained and experimentally verified why the reaction of a hydroxypropyl epoxide catalyzed by an antibody yields a tetrahydropyran rather than the THF largely produced with acid or base catalysts [*J Am Chem Soc*, **118** (1996) p.9204; *Chem Eng News*, **74** (40) (1996) p.35]. ❑

HKK

National Symposium on Advances in Chemical Reaction Engineering

A three-day National Symposium on Advances in Chemical Reaction Engineering was organised by the Department of Chemical Engineering in collaboration with the School of Biochemical Engineering at Institute of Technology, Banaras Hindu University, Varanasi, during March 5-7, 1997. The symposium was organised to commemorate the platinum jubilee of Chemical Engineering Education in the University The symposium was also a tribute to the long dedicated services of Dr Vijay Shankar, professor in the Department of Chemical Engineering who just retired from the active service of the University. The occasion also marked the begining of a yearly memorial lectures in the names of Prof. N N Godbole and Prof. Gopal Tripathi the first founder principal of the Department of Chemical Engineering and the first founder Director of the Institute of Technology, Banaras Hindu University, respectively.

The symposium was inaugurated by Prof. Hari Gautam, Vice-Chancellor, Banaras Hindu University who also addressed on the importance and involvement of chemical reactions in day-to-day life. Elaborating the theme of the symposium he said —"Chemistry is the mother of all Science. It invades every sphere of life which is nothing but a continuous chain of chemical reactions". He also stressed for an ultimate need of close interaction between the University and Industry for the betterment of education system and society. A souvenir brought out on the occasion was also released by him.

Prof. W U Malik, Ex-Vice-Chancellor, Allahabad University and member executive council, Banaras Hindu University, presided over the function. In his presidential address he stressed on the need of inter-disciplinary research in chemical sciences. Prof. Uma Shankar, Head, Department of Chemical Engineering welcomed the gusets and participants to the symposium. Prof Ashok Kumar, Dean, Institute of Technology briefly discussed the importance of chemical reaction engineering. Prof. S N Upadhyay, convenor of the symposium highlighted the principles of chemical reaction engineering and their applications in living systems, waste treatment and pollution control. He also stressed on the need for more intensive exchange of information on applied and fundamental aspects of reaction engineering. He hoped that this symposium would act as an effective forum for fruitful exchange of information between the R&D institutions and industry.

Speaking on the occasion, Prof. M Bhattacharya, Director, Institute of Technology said that the chemical engineering of the future will have to find ways to improve the technologies to meet worldwide challanges of health, safety and environment. Dr A S K Sinha, Secretary of the Symposium, while thanking all the dignitaries concluded the inaugural session with his own perception regarding chemical reaction engineering. He also expressed his gratitude to all the participants who came from different parts of the country and made this symposium a success.

The inaugural function was followed by a special lecture, two memorial lectures and eight plenary lectures by eminent chemical engineers. Besides, there were seven technical session . on: Reactor Operation and Optimization; Catalyst Development and Characterization (Part 1 and 2); Bio-chemical Reaction Engineering (Part 1 and 2); Reactor Modelling and Simulation and Kinetics of Chemical Reactions.

Delivering a special lecture on the occasion, , Prof. M M Sharma, Director UDCT, Mumbai, spoke on the reflections of a teacher, researcher, consultant and administrator in the University. While speaking on the occasion of First Prof. Gopal Tripathi Memorial Lecture he highlighted the disguised kinetics in multiphase reactions. Some novel aspects of liquid-liquid reactions were also

explained by him. The First Prof. N N Godbole Memorial Lecture was delivered by Dr T S R Prasada Rao, Director, Indian Institute of Petroleum, Dehradun. In view of the importance of petroleum refining industry in the recent years he discussed the new challenges in petroleum refining industry. He highlighted the role of R&D in converting those challenges into opportunities. He also explained the role of catalysis in the continuously changing senario of the petroleum industry in the Indian context.

The plenary lectures session opened with a talk on homogeneous catalysis by Prof. W U Malik (Roorkee University) who explained the metal catalysed photochemical decomposition of hexa-and octa-cyano complexes. In the second plenary lecture, Prof. S N Mukhopadhyay (IIT, Delhi) reviwed the opportunities and challenges of Vero-vaccinia Transfectional Fermentation Reaction Engineering. The usage of the solid state reactions in energy storage and micro-electronic applications was the subject of the lecture by Prof. M S Murthy (IISc, Bangalore). This was followed by a talk by Dr R P Verma (IOCL, Faridabad) who highlighted the recent developments in hydroprocessing catalysts, reactor engineering and process optimisation aspects. Prof. D Kunjru (IIT, Kanpur) illustrated the catalytic pyrolysis of *n*-heptane on unpromoted and potassium promoted calcium aluminates.

The first technical session focused on reactor operation and optimisation and the technical paper by the team of GNFC, Narmadanagar, was very much appreciated. The second and seventh session focused on catalyst development and characterisation. The paper by B N Srinivas (IIP, Dehradun) was well received by the audience. The focal theme of the third and sixth technical session was Biochemical Reaction Engineering. In this session one of the speaker Preeta Tyagi (Department of Chemical Engineering, BHU) elaborated the potential and limitations of membrane bioreactors and her work was also appreciated. Reactor modelling and simulation was the theme of the fourth technical session and a few papers were presented in it. Kinetics of chemical reactions was the theme for the fifth technical session and several papers were presented and discussed in detail.

On the concluding day there was a panel discussion which included response from delegates with respect to future course of action. It was also decided to bring out the proceedings in a book form.

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1998 SME International Conference on Education in Manufacturing

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Call for Papers

International Conference on Education in Manufacturing

October 14-16, 1998 • San Diego, California

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The purpose of the conference is to stimulate and enhance curriculum that prepares students to be contributing members of the global manufacturing workforce during the 21st century. It is an international forum for education, industry, and government leaders to exchange data and models for manufacturing education and to address vital issues that challenge the educational preparation of a workforce of manufacturing professionals with innovative solutions that meet industry needs.

Abstracts are invited that address the following topics of interest, including but not limited to:

- Accreditation standards and issues
- Assessment strategies and techniques
- Capstone courses
- Computer integration
- Continuous learning
- Curricular models
- Design of experiments
- Distance learning
- Educational technology
- Enhancing students' laboratory inferences
- Global similarities and differences
- Globalizing manufacturing education
- Holistic manufacturing education
- Industry-driven competencies
- Integration of new programs
- Keeping faculty current
- Laboratory design
- Laboratory instruction
- Learning organizations
- Manufacturing cooperative education
- Manufacturing systems design
- Multicultural programs
- Nontraditional manufacturing programs
- Partnership models
- Project-based instruction
- Projects and simulation
- Recruiting students
- Resource sharing
- Seamless education structures
- Specialized software
- Speeding innovation
- Students in manufacturing programs
- Teaching CAD/CAM/CIM
- Teaching new technologies
- Teaching the manufacturing infrastructure
- Teaming
- Use of human resources

Important Dates:

Abstracts due: May 31, 1997
Authors notified of acceptance: September 1997
Completed paper due for peer review: December 1997
Revised final paper due for publication: June 1998

To submit your abstract, please contact: Mark Stratton, Society of Manufacturing Engineers, One SME Drive, Dearborn, MI 48121, ph: 313-271-1500, ext. 506,
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Journal of Scientific & Industrial Research
(Incorporating *Research and Industry*)
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The **Journal of Scientific & Industrial Research** (Incorporating ***Research and Industry***) is published monthly to serve as an information link between the generators and users of technologies. It is addressed primarily to industrial entrepreneurs, technologists, engineers, technocrats and administrators in industry. Therefore, original research articles of practical interest to industry are invited for publication.

Contributions should have an economic bias, and wherever possible, cost estimates should be provided. They should be tersely written, giving only the significant results.

Besides, reviews on various branches of science and technology, science/industrial policy and management are also accepted.

Subject Coverage

Scientific Industrial Research

(i)Scientific investigations successful at the pilot-plant and in-plant trials.

(ii)Technology upgradation.

(iii)Development of cheaper and indigenous raw materials as replacement for uneconomical materials.

(iiv)Import substitution.

(v)Technologies for rural development.

(vi)Standardization and quality control.

(vii)Technologies of waste management.

(viii) Industrial R&D highlights.

Technology Management

(i)Success/failure stories in technology management.

(ii)Technology assessment.

(iii)Technology transfer.

(iv)Technology assimilation and adaption in different industries.

(v)Technology funding including venture capital.

(vi)Human Resource Development.

vii)Management.

(viii) Environmental management.

Industrial Development

(i)Policies, programmes and progress.

(ii)Critical profiles of industries—individual and sectoral.

(iii)Technology Forecasting .

(iv)International Collaboration.

(v)Fiscal incentives aimed at industrial development.

Books, monographs and technical bulletins on industrial methods and techniques as well as other data like production and demand statistics are accepted for review.

A critical analysis of papers presented at any Indian as well as international technology seminar/ symposium is also welcome.

Questions on the articles published in the journal, answers supplementing any of the published items, views, opinions, or suggestions on the various aspects of technology are welcome for inclusion in the column, 'readers react'.

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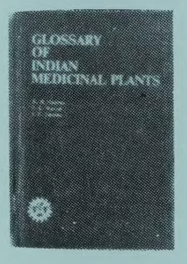

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